REPORT OF NOAA'S AIRBORNE PLATFORM REQUIREMENTS FOR THE TEN-YEAR PERIOD FROM FY 2003 – FY 2012

SUBMITTED TO
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Signature: ______________________________ **Date:** ______________________________

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EXECUTIVE SUMMARY

The National Oceanic and Atmospheric Administration (NOAA) conducts missions to analyze and predict changes in the Earth's environment and to conserve and manage the Nation's coastal and marine resources. To directly support NOAA's missions, the Aircraft Operations Center (AOC), which is part of NOAA Marine and Aviation Operations, maintains and operates a fleet of scientific research and reconnaissance aircraft that allow NOAA, other government agencies, non-profit organizations, and university scientists to precisely observe, measure, and chart the dynamics of coasts, oceans, and atmosphere.

The aircraft are operated, modified and maintained by civilians and NOAA Corps officers based at AOC, at the MacDill Air Force Base in Tampa, Florida. NOAA Corps commissioned officers and civilian flight engineers fly the aircraft, and FAA-certified mechanics and engineering support personnel maintain and repair them. AOC scientists, meteorologists, and engineers develop, build, and operate prototype and operational scientific instrumentation on the aircraft. Nearly all personnel at AOC perform operational flight duties, as well as maintain a full-time shore billet.

This report responds to Deputy Under Secretary for Oceans and Atmosphere Scott B. Gudes' memorandum of July 30, 2002: *Request for Report of NOAA's Platform Requirements* (Attachment 1). An analysis of NOAA's airborne platform requirements for the 10-year period from FY03 – FY12 is included, as well as recommendations for meeting these needs. The report was prepared by NMAO based on requirements solicited from NOAA's five line offices. In addition, a number of past studies were reviewed in compiling this report.

NOAA's far-ranging responsibilities in environmental prediction and stewardship cannot be adequately met without heavy reliance on airborne platforms.

NOAA's Aircraft Modernization Study – 1994

Mission Statement:

The mission of AOC is to safely and efficiently operate highly specialized NOAA aircraft in the most demanding flight regimes. AOC will conduct research, collect data on the atmosphere, environment, and geography on a global basis, as well as support the nation's disaster preparedness efforts.

Vision Statement:

The vision of AOC is to be the nation's choice for scientific aircraft support…operating an "on call" fleet dedicated to support diverse NOAA missions, with leading edge technology, committed to advancing global understanding and stewardship of the environment.

This report focuses on the aircraft requirements for supporting NOAA's four overarching goals as stated in NOAA's Strategic Plan. These goals are to serve society's needs for weather and water information; protecting, restoring, and managing coastal ocean resources through ecosystem management approaches; supporting the Nation's commerce with information for safe and efficient transportation; and understanding climate variability and change to enhance society's ability to plan and respond. Additionally, the report addresses NOAA's cross-cutting priorities for homeland security and integrating global environmental observation and data management systems as identified in NOAA's Strategic Plan.

NOAA's aircraft requirements are satisfied by a fleet of 13 highly specialized in-house aircraft and numerous contract aircraft. NOAA's in-house aircraft work as integral components of a national fleet of research aircraft – a partnership that includes other federal, academic, and private-sector aircraft. NOAA will continue to encourage and foster development of private-sector capabilities and utilize those capabilities to the extent they are able to meet NOAA's mission requirements. NOAA must operate and maintain a sufficient number of in-house aircraft to retain federal expertise, establish standards in core missions, and meet mission requirements that cannot otherwise be met in the private sector.

Long-term platform requirements for NOAA's fleet of aircraft are best understood by examining the trends presented in the past several years. Figure 1 shows total flight hours from Fiscal Years 1995 through 2002, reported by aircraft tail number and type of aircraft. Flight hours, taken alone, are a poor evaluation metric because NOAA aircraft are not self-tasking. Missions are flown during specific meteorological events, at specific tide windows, sun angle, etc.; therefore, the yearly hours flown can vary based on annual weather conditions and program requirements. Nonetheless, taken over a period of years, the data can be fairly compared.

Figure 1: Total Flight Hours by Tail Number FY95-FY02

AIRCRAFT	FY 95	FY 96	FY 97	FY98	FY 99	FY 00	FY 01	FY 02
Lockheed WP-3D Orion **N42RF**	260.7	281.7	447.9	545.0	146.5	309.8	182.2	458.5
Lockheed WP-3D Orion **N43RF**	327.7	348.2	152.8	161.9	303.9	191.5	300.8	165.1
AC-500S Shrike Commander **N47RF** **(Transferred from FAA in FY02)**	486.4	380.1	404.4	396.8	82.9	384.0	7.6	32.8
DeHavilland DHC-6 Twin Otter **N48RF**	368.8	227.8	514.7	618.7	405.0	440.1	330.3	626.2
Gulfstream G-IV SP **N49RF**	2.6	14.1	332.3	324.4	321.1	232.8	287.2	381.1
AC-500S Shrike Commander **N51RF**	231.9	445.5	434.1	274.5	333.4	144.9	528.3	334.6
Cessna Citation II **N52RF**	278.1	228.1	268.2	306.0	319.4	258.2	349.3	349.8
AC690A Turbo Commander **N53RF**	452.1	401.4	361.5	352.4	392.4	120.5	155.0	395.1
DeHavilland DHC-6 Twin Otter **N57RF**	297.1	392.4	386.5	438.1	704.1	498.8	585.4	722.1
McDonnell-Douglas MD-500D **N59RF**	6.4	0.0	0.0	89.1	197.4	188.4	104.2	29.7
Bell 212 Helicopter **N60RF** Disposed of aircraft in FY02	201.4	424.0	210.9	122.6	44.9	15.1	1.6	0.0
Bell 212 Helicopter **N61RF**	234.1	350.6	279.7	466.1	0.0	0.0	49.6	187.1
Lake Renegade Seawolf **N64RF**	247.3	180.3	217.8	189.3	74.1	27.1	107.8	148.2
Lake Renegade Seawolf **N65RF**	243.6	226.9	187.5	133.9	47.3	58.1	12.7	0.0
TOTAL BY YEAR	3,638.2	3,901.1	4,198.3	4,418.8	3,372.4	2,869.3	3,002.0	3,830.3

Figure 2 shows the annual aircraft services line item budget from the same time period, including reimbursable funds received from NOAA line offices and other agencies requesting flight hours. The appropriation supports the Aircraft Operations Center's ability to provide aircraft platforms for use by the NOAA line offices. The appropriation covers utilities, salaries, maintenance of aircraft, training, and other operational requirements, as well as base funding for some NOAA program flight-hour requirements. Aircraft flight-hour requests above the level of funding available in the base require fund transfers from the program to AOC.

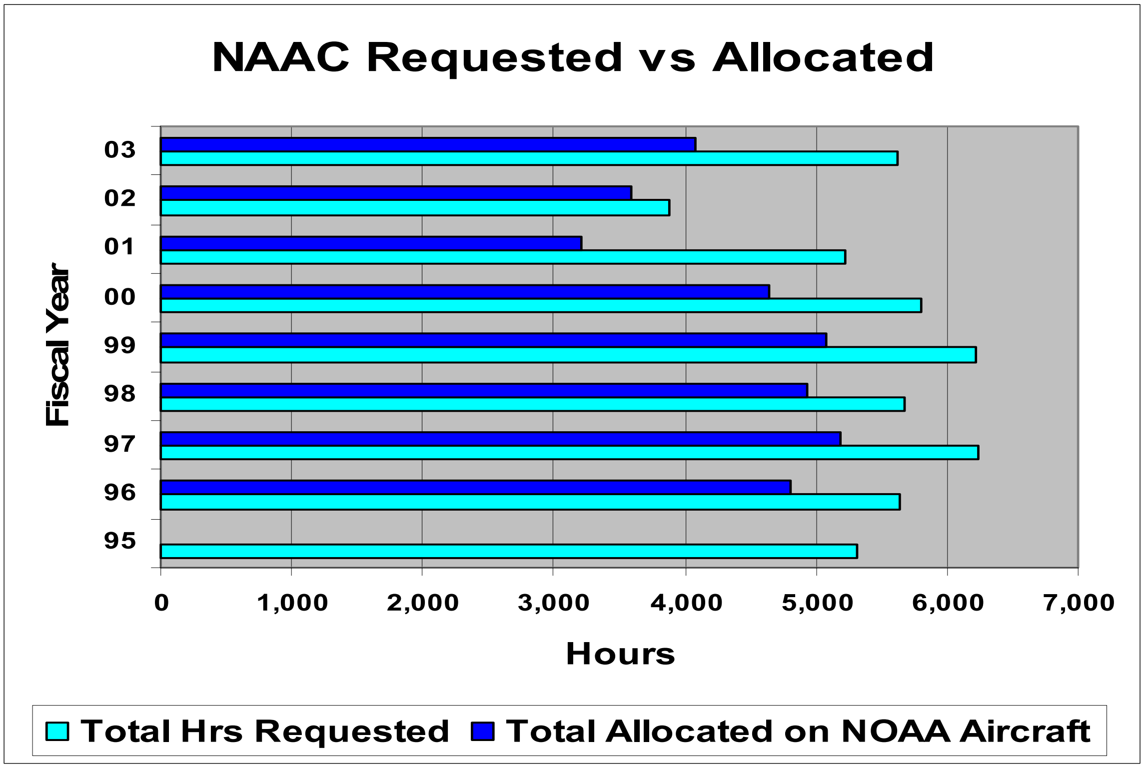
Figure 2 Aircraft Services Budget History

	FY 95	FY 96	FY 97	FY 98	FY 99	FY 00	FY 01	FY 02
Appropriation	**$10,453**	**$9,141**	**$10,000**	**$11,224**	**$10,500**	**$10,760**	**$11,809**	**$14,684**
Fund Transfers	2420.1	1724	2290.9	2751.7	1343.1	1219.4	2676.3	2394.7

The flight-hour trends suggest that aircraft project support has steadily increased over the past three years. Aircraft flight time supported by the aircraft services line item is allocated each year by the NOAA Aircraft Allocation Council (NAAC). The NAAC is composed of the Assistant Administrator of each line office and is chaired by the Deputy Under Secretary for Oceans and Atmosphere. Flight hours requested in excess of the available funding provided by the aircraft services base are paid for by the programs. The NAAC annually develops two allocation plans for aircraft, one for base-funded programs, and the other for non-base funded and inter-agency reimbursable programs. These plans reflect available scheduling on all of NOAA's platforms. Six aircraft -- two WP-3Ds, the G-IV, the Citation II, and the snow survey Shrike and Turbo Commanders -- flew base-funded projects in FY02 that accounted for 1994.4 flight hours. The remaining 1835.9 hours were flown as a result of funds being transferred to the Aircraft Operations Center. For FY00 – FY03, the Aircraft Operations Center has not raised its in-house (NOAA) light aircraft user fees, which were cited in *NOAA Light Aircraft Operations: An Independent Internal Assessment, February 2000 Study* by Mitretek Systems, Inc., as being 32 percent less expensive than fees charged for commercial aircraft use. Additionally, many of the aircraft are significantly modified and instrumented for the mission(s) they perform, making contracting in some cases difficult. NOAA line offices can choose whatever aircraft they want to support their missions; therefore, AOC aircraft must remain competitive.

Figure 3 shows the number of flights hours requested for in-house aircraft by the line offices for FY95 – FY03 and those hours allocated each year by the NAAC. The differences between the requested and allocated flight hours are a result of available funds and platform scheduling conflicts. The graph indicates that the requirement for airborne data collection requested by the line offices utilizing in-house resources exceeds both the capability and budget of the Aircraft Operations Center.

Figure 3: Flight hours requested by NOAA programs to be flown on in-house assets

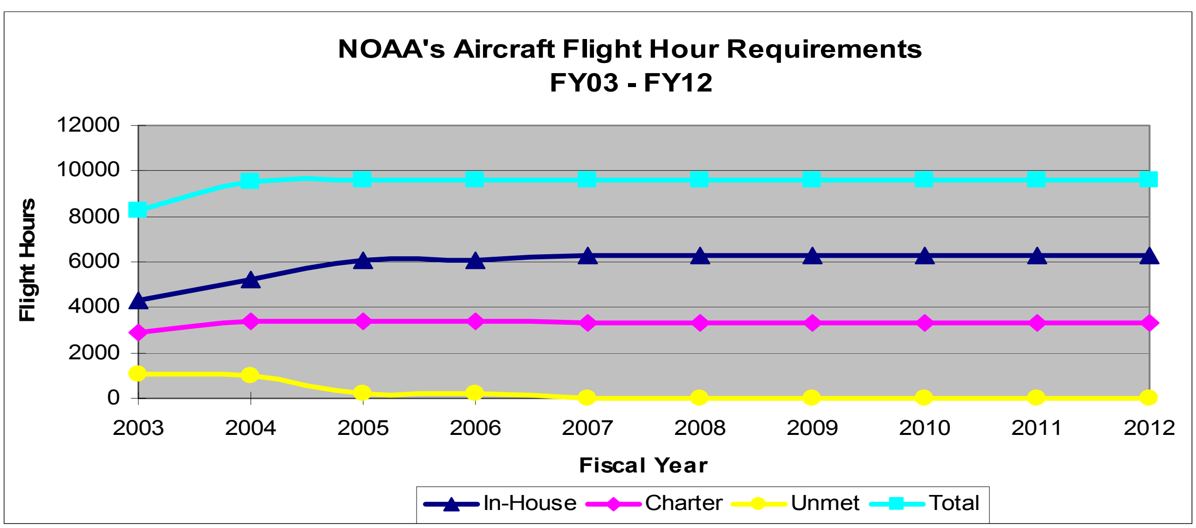


Performance: In preparation for writing this report, NMAO queried all NOAA line offices about their future aircraft flight-hour needs. The data showing the proposed mix of in-house and charter flight hours needed to meet NOAA's aircraft requirements by mission category for FY03-FY12 is contained in Figure 4. Not included in that table are significant requirements projected for unmanned flight hours utilizing the Global Hawk Unmanned Aerial Vehicle (6000 flight hours annually from FY08 – FY10) in support of global observation.

Figure 4: NOAA (Manned) Flight Hour Requirements FY03 – FY12

Weather & Water Impacts										
In-House	1660	1810	2465	2465	2660	2660	2660	2660	2660	2660
Air Force Reserve NWS Support	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600
Charter	705	680	655	630	630	630	630	630	630	630
Unmet/Unknown	220	770	195	195	-	-	-	-	-	-
Coastal/Ecosystem										
In-House	2030	2365	2415	2365	2415	2365	2415	2365	2415	2365
Charter	2075	2600	2600	2600	2600	2600	2600	2600	2600	2600
Unmet/Unknown	750	-	-	-	-	-	-	-	-	-
Commerce/Transportation										
In-House	347	415	425	435	435	435	435	435	435	435
Charter/Unknown	-	-	-	-	-	-	-	-	-	-
Unmet/ Unknown	-	-	-	-	-	-	-	-	-	-
Climate Variability/Change										
In-House	175	450	655	655	655	655	655	655	655	655
Charter	100	100	100	125	100	100	100	100	100	100
Unmet/Unknown	120	205	-	-	-	-	-	-	-	-
Homeland Security										
In-House	105	155	105	155	105	155	105	155	105	155
Charter/Unknopwn	-	-	-	-	-	-	-	-	-	-
Unmet/Unknown	-	-	-	-	-	-	-	-	-	-
All Missions	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
In-House	4317	5195	6065	6075	6270	6270	6270	6270	6270	6270
Charter	2880	3380	3355	3355	3330	3330	3330	3330	3330	3330
Unmet/Unknown	1090	770	195	195	-	-	-	-	-	-
Total	**8287**	**9345**	**9615**	**9625**	**9600**	**9600**	**9600**	**9600**	**9600**	**9600**

Charter flight hour data is incomplete due to new reporting procedures
Charter flight hours do not include contracts for services that include imbedded flight hours
The Outyear requirements are not clearly defined
Air Force Reserve flight hours in support of NWS missions not included in totals



In FY03, NOAA's total flight-hour requirements for all mission areas is 8287 hours. NOAA- operated aircraft are projected to provide 4317 hours, or approximately 52 percent of the FY03 requirement. Outsourcing is projected to cover 2880 hours or approximately 35 percent of the total requirement (Figure 5). It is important to note that the outsourcing hours listed above do not include a significant number of aircraft flight hours imbedded in contracts for services for hydrographic surveys, coral reef mapping, airport surveys, coastal mapping, and marine mammal assessments, where contractors provide a finished product or report to NOAA. (See Figure 6)

Figure 5

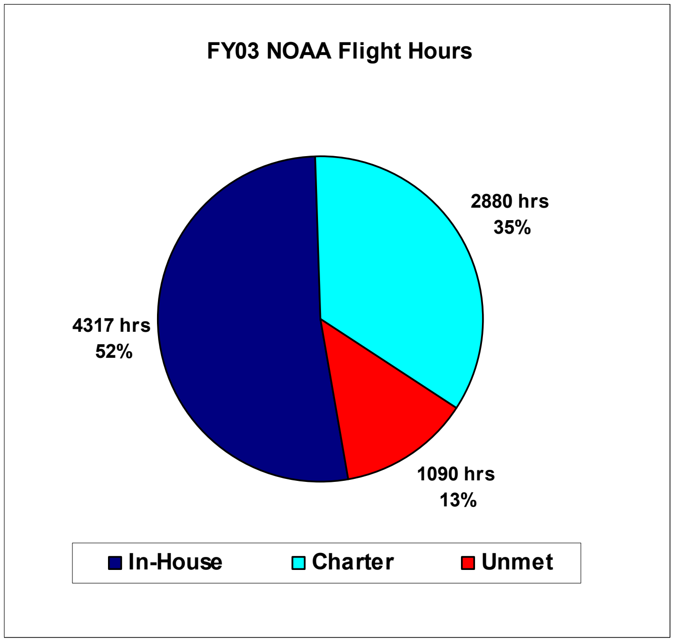


Figure 6: FY03 Contracts for Services Including Imbedded Flight Hours

Line Office	Mission	Contract Total Estimate	FY
NOS	Hydrographic Surveys	$4,000,000	2003
NOS	Coral Mapping	$1,050,000	2003
NOS	Airport Surveys	$100,000	2003
NOS	Shoreline Mapping	$3,000,000	2003
NMFS	Harbor Porpoise Surveys	$54,700	2003
	Total	**$8,204,700**	

In addition to NOAA aircraft flight hour requirements, NOAA's National Weather Service (NWS) has a requirement (up to 1600 hours of heavy-aircraft flight time) to acquire low-level hurricane reconnaissance data. Currently provided through Air Force Reserve reconnaissance flights, these data are vital for NOAA's model initialization, track, and intensity forecasts, and will continue to be very important for the next 10 years. This ongoing requirement is not addressed by this report, but if the mission were to be dropped by the Air Force Reserve due to changes in Department of Defense priorities, it could require significant expansion and restructuring of NOAA's heavy-aircraft platform capabilities.

Aircraft requirements are expressed in flight hours. While important, flight hours don't tell the whole story about how research aircraft are utilized. As previously stated, NOAA aircraft are not self-tasking and have to be removed from operational service to be outfitted with scientific instrumentation. Therefore, the yearly requirements will vary based on annual weather conditions and program requirements. In an effort to paint a more comprehensive picture of fleet utilization and performance, NMAO has recently developed a new measure, called the "utilization factor," to be implemented beginning in FY03. The utilization factor will augment flight hours and captures total platform usage -- including data collection, standing by for operational project parameters, aircraft instrumentation, scheduled maintenance, and crew training. NMAO is now capturing FY03 utilization factor data; however, the timing of this report necessitates reporting flight-hour requirements in the historical fashion.

NOAA's mission: "*To understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet the Nation's economic, social, and environmental needs*" is directly impacted when NOAA programs are unable to collect the data they need to aid in critical decision-making and advance overall scientific research. Approximately 1090 hours, or 13 percent of NOAA's FY03 aircraft flight hour requirements, will likely go unmet by either NOAA aircraft or outsourcing. The impacts of unmet requirements are discussed in each mission area of this report. A combination of factors, including scheduling conflicts with the existing resources and insufficient funding to support the program flight-hour requests, results in needs going unmet. It should be noted that prior to FY02, NOAA did not have a "corporate picture" of the amount of aircraft outsourcing that was being done to accomplish NOAA missions. The individual line offices took care of their outsourcing needs through their respective Administrative Support Centers, and there was no single collection point for this data. In an effort to track NOAA expenditures and utilization of contract aircraft services, NMAO began to track aircraft charter activity for NOAA.

These data were reported in the Federal Aviation Interactive Reporting System (FAIRS) in FY01 at the direction of the Office of Management and Budget and the General Services Administration. As procedures for reporting outsourcing requirements to NMAO have only recently been implemented, the data are incomplete.

NOAA's fleet consists of 13 scientific research and reconnaissance aircraft. An overview of current aircraft capabilities is contained in Figure 7.

Figure 7: NOAA Aircraft Overview
(as of January 22, 2003)

Aircraft Type	GIV-SP	WP-3D	CE-550	AC-690A	DHC-6	AC500S	B-212	MD-500	LA-27
Manufacturer Common Name	Gulfstream	Lockheed P-3	Cessna Citation	Gulfstream Turbo Cdr	DeHavilland Twin Otter	Rockwell Shrike	Bell Helicopter	Hughes Helicopter	Lake
Number Owned	1	2	1	1	2	2	1	1	2
Year Built (Age in FY03)	1994 (9)	1975 1976 (27 & 28)	1978 (25)	1974 (29)	1981 1980 (22 & 23)	1975 1977 (28 & 26)	1979 (24)	1979 (24)	1991 1991 (12)
Total Time in flight hours	1876	8914 7839	7315	11827	13325 15775	12462 8553	9089	3202	1464 1195
Max Range	4000NM	3000NM	1610NM	1000NM	840NM	860NM	375NM	300NM	1500NM
Max Endurance	10.3 hrs	11.5 hrs	5 hrs	6 hrs	7.5 hrs	4.5 hrs	3.5 hrs	2.8hrs	8 Hrs
Operational Speeds	Mach .76 – Mach .88	180-350 *KIAS	350 *KIAS	120 – 250 *KIAS	80-160 *KIAS	90–160 *KIAS	Hover–120 *KIAS	Hover–156 *KIAS	135 *KIAS
Service Ceiling	45,000'	30,000'	43,000'	31,000'	12,500' or 25,000' w/O_2	12,500' or 18,000 w/O_2	12,500'	12,500'	12,500'
Useful Payload	32,000lbs	58,000lbs	6,848lbs	3,420lbs	4,400lbs	1,450lbs	4,000lbs	1,450lbs	1250lbs
Crew (pilots-crew)	2-13	4-20	2-4	2-7	2-8	2-7	1-15	1-4	1-4

***KIAS = Knots Indicated Air Speed**

The NOAA aircraft fleet is a well-maintained but aging conglomerate of versatile platforms, and all aircraft have been modified to support NOAA program requirements. For a summary of the capabilities of each aircraft, refer to Appendix A: NOAA Aircraft Summaries. Critical decisions and recommendations are included in this report based on NOAA line office requests for support. These recommendations are ranked in priority and range from "necessary to maintain current capabilities" to "required to increase capabilities" in order to satisfy current and future NOAA requirements.

Priority Issues to Maintain Existing Capabilities

<u>Turbo Commander N53RF – Critical Issue</u>

Acquisition of a Turbo Commander replacement platform is a key component in NWS's effort to meet its goal to increase the accuracy and timeliness of Advanced Hydrologic Prediction Services (AHPS) forecasts and warnings across the conterminous United States and in Alaska. Without a major engine overhaul, the Turbo Commander will reach the end of its useful life this fiscal year.

To complete all aspects of the FY03 mission objectives, NOAA should either dispose of the existing platform and initiate a lease-to-own procurement of a renaissance or used, but in better condition, Turbo Commander or conduct the necessary renaissance on the existing platform no later than March 2003. The lease-to-own arrangement would bridge a gap between March 2003 and the time that a replacement aircraft can be purchased with FY04 funding of $1.55M.

Rockwell Shrike Commanders–N47RF andN51RF

NOAA's Shrike Commanders support Coastal Ecosystem, Commerce and Transportation, as well as Weather and Water Impact missions. The two aircraft (N47RF and N51RF) are recommended for phased replacement in FY10 and FY11, respectively. An estimated $5M will be required to replace N47RF, and $5.1M to replace N51RF.

Lockheed WP-3D Orions – N42RF and N43RF

The NOAA WP-3D Orions primarily support Weather and Water Impacts, as well as Climate Variability missions. By 2010, NOAA will be at a critical decision point regarding the WP-3D. Plans should be initiated during that year to place existing NOAA WP-3Ds in a Service Life Extension Program (SLEP). Details about this program are in Chapter 3 of this report. An in-kind replacement option would require start up of commercial production of the aircraft for the military or a special request for production from NOAA. In the meantime, each WP-3D will undergo Standard Depot Level Maintenance (SDLM) inspection on the following schedule:

N42RF SDLM years – 2003, 2007, 2011

N43RF SDLM years – 2002, 2006, 2010

Citation II – N52RF

The NOAA Citation II currently supports Commerce and Transportation, Coastal Ecosystem, and Homeland Security missions. This platform is modified to support photogrammetry and remote sensing and was utilized to provide data to search and rescue and recovery personnel on the ground at the World Trade Center after September 11, 2001. As the jet aircraft is approaching the end of its useful life, the Citation II should be disposed of in 2007 after an enhanced replacement aircraft is procured no later than 2006. Careful consideration to current and future mission requirements should dictate the type of replacement aircraft. Given existing and forecast mission requirements, a Citation Sovereign should be evaluated as a replacement for the Citation II. The projected replacement cost is $20M to purchase the aircraft and modify it to complete NOAA remote-sensing and photogrammetric missions.

Gulfstream IVSP – N49RF

The Gulfstream-IV currently supports Weather and Water Impacts, and Climate Variability missions. Major modifications are planned to increase the aircraft capabilities. Refer to Appendix B: NOAA G-IV System Upgrades FY03-FY04 for detailed description of planned modifications. Although the Gulfstream-IV is currently supporting climate and weather missions, the aircraft could be used for global climate studies immediately and eventually be used by any NOAA program that requires a high-altitude remote-sensing and air-sampling platform. Significant scheduled maintenance includes an engine midlife in 2004 and overhaul in 2014.

Bell 212 Helicopter-N61RF and McDonnell Douglas MD-500 Helicopter-N59RF

NOAA's National Marine Fisheries Service (NMFS) requested a replacement for the current MD 500 single-engine helicopter that would be capable of operating off NOAA ships. This twin-engine aircraft would increase the safety margin for personnel operating far offshore. NOAA should dispose of the MD-500 (estimate $350,000) and the Bell 212 (estimate $900,000) in FY05 and use the funds to offset the purchase of a more versatile twin-engine platform (estimated cost $6M to purchase and modify for NOAA programs) that can operate from the NOAA Ship DAVID STARR JORDAN and its replacement vessel. An estimated additional $3M would be required to modify the replacement ship for helicopter operations.

Replacement of NOAA Research Airborne Data-Collection Capability

An experimental Long EZ was used to acquire low-level atmospheric flux measurements until the aircraft was lost in an accident in August 2002. To replace the lost capability, NOAA's Office of Oceanic and Atmospheric Research (OAR) requires a light airplane instrumented to support climate studies and air chemistry research. Several missions are in jeopardy due to the loss of the Long EZ and its instrumentation. The acquisition of a Velocity airplane is currently under consideration to accommodate expanding atmospheric measurement capabilities while retaining the characteristics of an operationally simple airplane. OAR asked AOC to help acquire, maintain, and support an aircraft to replace the Long-EZ. The estimated acquisition and modification cost for the Velocity is $0.3M.

Recommendations for Removal from Service

Lake Amphibian LA-27 – N64RF and N65RF

Currently, the only mission identified for the Lake aircraft is supporting the Channel Islands National Marine Sanctuary (CINMS) coastal survey mission. On average, this aircraft is flown 160 hours a year over 65 days. Due to the limited mission requirements for this type of platform, AOC is planning to dispose of both Lake aircraft in FY03 and FY04. Program requirements at CINMS can be accomplished by the use of other existing NOAA aircraft or through aircraft charter.

Recommendations for Enhancement of Capabilities

Second High-Altitude Jet

NWS and OAR have indicated that an additional high-altitude jet aircraft would improve NOAA's 24-hour, high-altitude hurricane operations and allow for greater flexibility to support other NOAA climate projects during the hurricane season. If the procurement of an equivalent high-altitude aircraft were initiated in 2006, the aircraft would be mission-ready by late FY08. An additional high-altitude jet would require 11 new positions (three NOAA Corps pilots, one GS mechanic, two GS flight meteorologists, five GS engineering support personnel). Acquisition cost is estimated at $90M.

Lockheed P-3 Orions

An additional P-3 aircraft would be immediately useful to support air chemistry research projects. This additional aircraft could support remote-sensing and surveillance missions over the main and Northwest Hawaiian Islands, and back up the current WP-3D's during hurricane season. AOC has identified two options for adding an additional P-3 to the fleet: **option 1:** transfer of an active scientific P-3 from the U.S. Navy to NOAA, and **option 2:** extraction of a Navy P-3 from the desert storage. The suggested acquisition date is 2003, with a SDLM in 2005 and 2009. An additional P-3 would require 12 new positions (three NOAA Corps pilots, one NOAA Corps navigator, one GS equipment specialist, one GS mechanic, one GS flight meteorologist, five GS engineering-support personnel). The cost to acquire this aircraft is $6.5M in one-time PAC funds, and $1.9M in operating funds. It is recommended that a P-3 replacement study commence in FY10.

DeHavilland Twin Otters–N48RF and N57RF

NOAA's Twin Otters support Coastal Ecosystem, Commerce and Transportation, and Climate Variability missions. In addition, they have been used to conduct natural disaster surveys, and those capabilities could be applied to homeland security. The useful life of both existing Twin Otters extends to at least 2020; however, the project load on NOAA's existing Twin Otters, as well as the number of NOAA projects that have not been supported due to schedule constraints, suggest that at least one additional NOAA Twin Otter would benefit NOAA line offices. Members who attended the NOAA Light Aircraft Forum in November 2001 also support the acquisition of another NOAA-operated Twin Otter. Funds obtained through the disposal of a NOAA Bell 212 in FY02 ($945,000) will be used to offset the cost of acquiring a Twin Otter in FY03 (estimate $1.9 million); discussions are underway to identify the additional funds necessary to purchase the aircraft. This additional Twin Otter will require maintaining the number of current pilot billets and reassigning existing maintenance personnel. The fleet of three Twin Otters (N48RF, N57RF, NXXRF) are recommended for wing replacement in FY10-FY12, respectively. The estimated cost for re-winging each airplane is $1M - $1.2M.

Unmanned Aerial Vehicles

NOAA atmospheric research scientists are exploring the concept of a new long-term global observing system to provide detailed profiles of the Earth's atmosphere and oceans. In addition to using satellites and ocean buoys to acquire data to support profiling, this system would use unmanned aerial vehicles

(UAV's) in a large range of flight profiles to collect data around the clock. The atmospheric research community is interested in initiating a three- to five-year proof of concept mission beginning with procurement in FY05 and utilization of the Global Hawk UAV.

Assuming that the concept of using Global Hawks to improve long-term climate forecasts is proved, the research community would subsequently initiate an effort to operate a fleet of UAVs deployed from bases worldwide. In addition to UAVs, NOAA scientists are interested in experimenting with remotely piloted vehicles (RPVs). Most UAVs and RPVs have a greater range, duration, and ceiling than conventional light and heavy aircraft. In addition, operation of these vehicles in hazardous environments does not threaten human air crews.

Figure 8 summarizes the projected service life and fleet replacement recommendations listed above.

Figure 8: Projected Service Life and Recommended Replacement Schedule for NOAA Aircraft
(as of January 22, 2003)

Current/Replacement Aircraft	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
WP-3D N42RF 8914 Hours	SDLM				SDLM				SDLM	
WP-3D N43RF 7839 Hours				SDLM				SDLM		
Additional P-3 $6.5 M PAC + 1.9M ORF	Acquire Aircraft		SDLM				SDLM			
G-IVSP N49RF 1876 Hours		Engine Midlife								
Additional High Altitude Jet ($90 M)		Submit FY06 Initiative		Procure	Instrument					
Citation II N52RF 7316 Hours					Dispose					
Citation Replacement ($20 M)		Submit FY06 Initiative		Procure and Instrument						
Twin Otter N48RF 13325 Hours									Re-Wing	
Twin Otter N57RF 15775 Hours								Re-Wing		
Additional Twin Otter ($1.4 M)	Procure									Re-Wing
Turbo Commander N53RF 11827 Hours	Dispose est $400K	Apply Funds towards Replacement Lease to Own Aircraft								
Turbo Commander Replacement $1.55M	Initiate Lease to Own	Complete Procurement with FY04 Funds								
Shrike Commander N47RF 12462 Hours								Replace		
Shrike Commander N51RF 8553 Hours									Replace	
Bell 212 N61RF 9089 Hours			Dispose est $900K	Apply Funds towards Light Twin Helo						
MD-369 (500) N59RF 3202 Hours			Dispose est $350K	Apply Funds towards Light Twin Helo						
Light Twin Engine Helicopter ($7M)	Submit FY05 Initiative		Procure and Instrument							
Lake LA-27 N64RF 1464 Hours		Dispose est $100 K	Apply Funds towards Light Twin Helo							
Lake LA-27 N65RF 1195 Hours	Dispose est $100K	Apply Funds towards SERA								
LO Funding Required										
Small Environmental Research Aircraft (SERA)	Procure and	Instrument								
5 Global Hawk (UAV)	Submit FY05 Initiative		Procure and	Instrument						

- Blue: Aircraft Required by NOAA through FY12.
- Red: Aircraft Sold by FY12.
- Green: Aircraft Acquisitions Required to Maintain NOAA Capabilities through FY12.
- Gray: Aircraft Acquisitions Required to Increase NOAA Capabilities through FY12.

Airborne scientific instrumentation has been advancing with quantum leaps. In addition to the platform replacements and upgrades suggested above, NOAA's airborne platforms require upgrades to keep pace with emerging technology. These requested upgrades are detailed under the appropriate mission goals. Required regulatory upgrades for aircraft navigation and communication systems are also outlined in the report.

Cost: The incremental funding above the FY04 base needed to meet changing aircraft platform and instrumentation requirements of NOAA's programs over the next 10 years is $140.5M in PAC funds, and an $8.1M increase in ORF funds. These estimates are based on FY03 dollars. Figure 9: Funding Required to Accomplish Aircraft 10-Year Plan ($ in millions) summarizes the ORF and PAC projections for the next 10 years.

Figure 9: Funding Required to Accomplish Aircraft 10-Year Plan ($ in millions)*

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ORF (Aircraft Services)	16.2	18.3	20.2	23.3	22.0	23.1	23.5	27.0	27.1	26.4
PAC (Aircraft Replacement)	8.4	9.1	17.6	101.9	1.9		1.9	7.9	8.1	1.2
Total	24.6	27.4	37.8	125.2	23.9	23.1	25.4	34.9	35.2	27.6

* Does not include UAV cost estimate

When planning budget requirements to meet aircraft flight-hour needs, it must be understood that not all of the flight hours scheduled on NOAA aircraft are "base funded." For example, in FY03, only 1870 (or 43 percent) of the total 4312 hours scheduled on NOAA platforms are funded by the aircraft services line item in NOAA's budget. The funding for the remainder of the flight hours comes directly from the programs (NOAA line offices and other agencies) requesting flight hours.

Personnel: Consideration and planning must also be given to personnel and facilities to carry out the recommendations regarding replacing and upgrading the NOAA aircraft fleet; 33 additional FTEs will be required over the next 10 years. Figure 10: FTE Requirements to Accomplish Aircraft 10-Year Plan shows projections of these FTE increase requirements.

Figure 10: FTE Requirements to Accomplish Aircraft 10 Year Plan

	2003	2004	2005*	2006**	2007	2008	2009	2010	2011	2012
ORF (Aircraft Services)	92	102	114	114	125	125	125	125	125	125
PAC (Aircraft Replacement)	0	0	0	0	0	0	0	0	0	0
Total	92	102	114	114	125	125	125	125	125	125

* Additional WP-3D
** Additional High-Altitude Jet

Facilities: NOAA's Aircraft Operations Center currently is allocated the use of a large World War II vintage hangar as well as three additional buildings at no lease cost. In turn, NOAA is responsible for the facilities maintenance of these buildings, required utilities, and a portion of the overhead necessary to operate MacDill AFB. The host-tenant support agreement between the Air Force Air Mobility Command and the Department of Commerce for AOC is reviewed every five years and expires in April 2003. Recent communications with the 6th Air Mobility Wing Commander, Major General (sel.) Hodges, indicate that the Air Force may be reluctant to re-sign the standard five-year occupancy permit and will likely opt for an interim two-year agreement affording AOC continued operations at MacDill AFB through April 2005. This limited permit is due to increased demand for ramp and hangar space that may be required to support an increased number of Air Force aircraft at the base. The future Air Force plans at MacDill are unfolding at this time; AOC has been invited to participate in these discussions by the Wing Commander. Every effort will be made to accommodate both the increased Air Force and continued NOAA mission requirements.

If asked to vacate our present facility, indications suggest that the Air Force would invite NOAA to build a new hangar and office facility somewhere on the MacDill AFB property. In FY03, AOC will initiate a market analysis to determine the funding that would need to be allocated to either support this effort or move the entire operation to another location.

1.0 Introduction

NOAA's mission to understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet the Nation's economic, social, and environmental needs faces new urgency given the intensifying national needs of the environment, the economy, and public safety. NOAA's role in facing these challenges is to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, manage the Nation's living marine resources, and foster global environmental stewardship. NOAA aircraft support a multitude of NOAA missions in a variety of environments:

In a hurricane 600 hundred miles southeast of Miami, two NOAA WP-3D Lockheed Orion aircraft coordinate entry turns toward storm center from opposite sides of the cyclone. In spite of the differences of altitude and relative wind, the two aircraft penetrate the hurricane eyewall simultaneously on orthogonal headings and cross each other at the storm center at exactly the same time, both assessing the storm with a staggering array of sensors and sophisticated radar. For a brief moment, the two flight crews can see each other in the relative clear of the hurricane eye, but now must focus on their respective exit penetrations. High overhead, near the storm center, the NOAA Gulfstream-IV high-altitude jet profiles the vertical structure of the storm and its environment, and serves as a communications relay between the two WP-3Ds as the severe rain attenuates the radio signals between the two lower-flying aircraft. All of these data collected are being transmitted in near real time to the National Centers for Environmental Prediction and the National Hurricane Center, and provide forecasters and researchers critical information necessary to predict the hurricane's track and intensity. The flights will continue as long as the storm threatens to make landfall. Later in the year, the G-IV will fly winter storm reconnaissance in the northern Pacific Ocean, penetrating polar jet cores with high-altitude wind speeds greater than 200 knots. The WP-3Ds will fly air chemistry and spring thunderstorm projects in the winter and spring.

Banking low over the ocean 75 miles east of Cape Cod, the crew and observers in a NOAA DeHavilland Twin Otter are surprised to locate a pod of right whales after weeks of no contact. They have been tracking the animals, from the coast of Florida to Maine, for an entire year to better understand and protect this threatened species. It's late in the season, and all had assumed the whales had begun to migrate south. Their finding will necessitate the closure of fishing grounds located near the sighting. Meanwhile, in a heavily instrumented sister Twin Otter, the flight crew and scientists precisely measure trace gases at low altitudes near heavily populated eastern cities. The two aircraft are immensely popular and are ambitiously scheduled to support a variety of diverse projects for fisheries and research throughout the year.

In the Wind River Mountain Range in Wyoming, a flight crew in the NOAA Rockwell Turbo Commander crosses the crest of a mountain and steeply pitches the aircraft down to initiate a snow-water-equivalent data-collection survey line. To keep their airspeed below 120 knots, they extend the landing gear for increased drag. Flying low in mountainous terrain, the crew needs to visually steer a predetermined track as the gamma radiation-detection instrumentation in the aircraft measures energy emitted from the soil beneath the snow cover. The snow-water- equivalent data gathered on this 20-day survey will enable NOAA hydrologists to assess the snow pack throughout the western United States, providing vital data to NOAA water resource managers. At the same time in the smaller and less powerful NOAA Rockwell Shrike Commander, a flight crew makes the same type of measurements in the eastern half of the country to assess the threat of snowmelt flooding in support of NOAA's National Weather Service's River Forecast Offices. Recently, snow survey lines were established in the state of Alaska.

In the aftermath of the World Trade Center and Pentagon attacks, crew aboard the NOAA Cessna Citation II use its unique dual-optical port capability to accurately measure the debris field, using precision kinematic GPS mapping techniques that capture concurrent LIDAR and photogrammetric imagery. These images aid in the search for victims and the subsequent removal of debris to clear the site. The small jet is a research test bed for developing advanced remote-sensing instrumentation and techniques necessary to advance NOAA's near-shore charting mission. The aircraft operates throughout the United States and its territories.

In the equatorial Pacific, the MD-500 Hughes 500 helicopter lifts off the tiny flight deck of the NOAA Ship DAVID STARR JORDAN to perform tuna and porpoise population studies. The aircraft carries scientists and equipment necessary to assess the health of various dolphin species; the data are used to determine politically sensitive international fishing catch limits. The ship and aircraft set sail from San Diego in June, and will finally return to home port in December. The shipboard operation of this single-engine helicopter is considered to be some of the most demanding flying found within NOAA.

These are but a few examples of NOAA programs that currently require aircraft to collect data necessary to perform their missions. NOAA is moving towards leading-edge airborne technology utilizing Unmanned Aerial Vehicles to monitor and observe the earth around the clock. NOAA's in-house aircraft work is an integral component of a national fleet of research aircraft – a partnership that includes other federal, academic, and private sector aircraft. NOAA will continue to encourage and foster development of private-sector capabilities and utilize those capabilities to the extent they are able to meet NOAA's mission requirements. NOAA must operate and maintain a sufficient number of in-house aircraft to retain federal expertise, establish standards in core missions, and meet mission requirements that cannot otherwise be met in the private sector.

NOAA's far-ranging responsibilities in environmental prediction and stewardship cannot be adequately met without heavy reliance on airborne platforms.

NOAA's Aircraft Modernization Study – 1994

Currently, NOAA does not have a single long-range plan to address the requirements for airborne data collection. A number of individual studies have been completed to address parts of the need, and are highlighted in Chapter 6 of this report.

Meeting Airborne Platform Requirements

In FY03, NOAA's total flight hour requirements identified by NOAA line offices for all mission areas is 8287 hours. NOAA-operated aircraft are projected to provide 4317 hours, or approximately 52 percent of the FY03 requirement. Outsourcing is projected to cover 2880 hours, or approximately 35 percent of the total requirement. It is important to note that the outsourcing hours listed do not include a significant amount of aircraft flight hours imbedded in contracts for services for hydrographic surveys, coral reef mapping, airport surveys, coastal mapping, and marine mammal assessments, where contractors provide a finished product or report to NOAA. (See Table 1)

Table 1: FY03 Contracts for Services Including Flight Hours

Line Office	Mission	Contract Total Estimate	FY
NOS	Hydrographic Surveys	$4,000,000	2003
NOS	Coral Mapping	$1,050,000	2003
NOS	Airport Surveys	$100,000	2003
NOS	Shoreline Mapping	$3,000,000	2003
NMFS	Harbor Porpoise Surveys	$54,700	2003
	Total	**$8,204,700**	

Approximately 1090 hours, or 13 percent of NOAA's FY03 aircraft flight-hour requirements, will likely go unmet. A combination of factors, including scheduling conflicts with the existing resources and insufficient funding to support the program flight-hour requests, are to blame for the unmet needs. NOAA's mission "*To understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet the Nation's economic, social, and environmental needs*" is directly affected when NOAA programs are unable to collect the data they need to aid in critical decision-making and advance overall scientific research.

In preparation for writing this report, NMAO queried all NOAA line offices about their future aircraft flight-hour needs. The data showing the proposed mix of in-house and charter flight hours needed by mission category for FY03-FY12 are contained in Table 2. Not included are significant requirements for unmanned flight hours utilizing the Global Hawk Unmanned Aerial Vehicle (6000 flight hours annually from FY08–FY10) for global observation. It should be noted

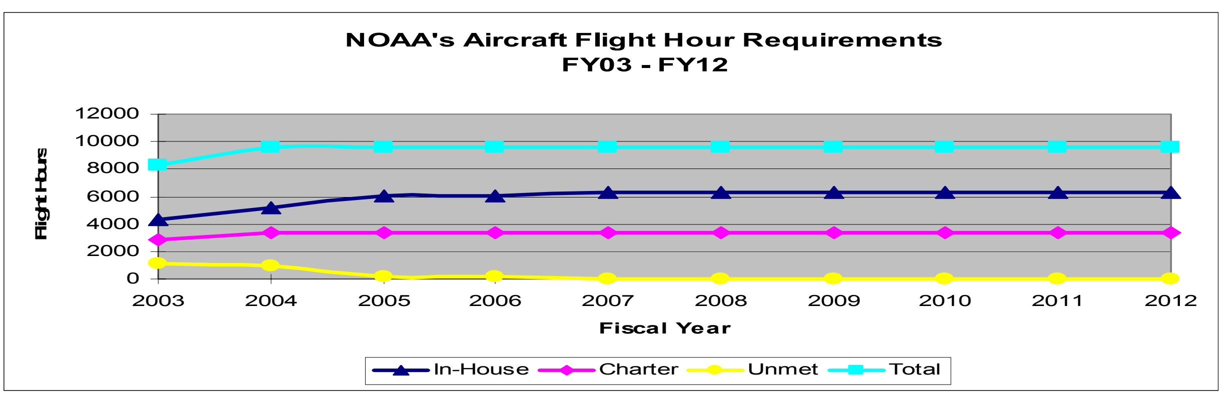
that prior to FY02, NOAA did not have a "corporate picture" of the amount of aircraft outsourcing that was being done to accomplish NOAA missions. The individual line offices took care of their outsourcing needs through their respective Administrative Support Centers, and there was no single collection point for these data. In an effort to track NOAA expenditures and utilization of contract aircraft services, NMAO began to track aircraft charter activity for NOAA. These data were reported in the Federal Aviation Interactive Reporting System (FAIRS) in FY01 as directed by the Office of Management and

Budget and the General Services Administration. As procedures for reporting outsourcing requirements to NMAO have only recently been implemented, the data are incomplete.

Table 2.0: NOAA (Manned) Flight-Hour Requirements FY03 – FY12

Mission	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Weather & Water Impacts										
In-House	1660	1810	2465	2465	2660	2660	2660	2660	2660	2660
Air Force Reserve NWS Support	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600
Charter	705	680	655	630	630	630	630	630	630	630
Unmet/Unknown	220	770	195	195	-	-	-	-	-	-
Coastal/Ecosystem										
In-House	2030	2365	2415	2365	2415	2365	2415	2365	2415	2365
Charter	2075	2600	2600	2600	2600	2600	2600	2600	2600	2600
Unmet/Unknown	750	-	-	-	-	-	-	-	-	-
Commerce/Transportation										
In-House	347	415	425	435	435	435	435	435	435	435
Charter/Unknown	-	-	-	-	-	-	-	-	-	-
Unmet/ Unknown	-	-	-	-	-	-	-	-	-	-
Climate Variability/Change										
In-House	175	450	655	655	655	655	655	655	655	655
Charter	100	100	100	125	100	100	100	100	100	100
Unmet/Unknown	120	205	-	-	-	-	-	-	-	-
Homeland Security										
In-House	105	155	105	155	105	155	105	155	105	155
Charter/Unknopwn	-	-	-	-	-	-	-	-	-	-
Unmet/Unknown	-	-	-	-	-	-	-	-	-	-
All Missions	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
In-House	4317	5195	6065	6075	6270	6270	6270	6270	6270	6270
Charter	2880	3380	3355	3355	3330	3330	3330	3330	3330	3330
Unmet/Unknown	1090	770	195	195	-	-	-	-	-	-
Total	**8287**	**9345**	**9615**	**9625**	**9600**	**9600**	**9600**	**9600**	**9600**	**9600**

Charter flight hour data is incomplete due to new reporting procedures
Charter flight hours do not include contracts for services that include imbedded flight hours
The Outyear requirements are not clearly defined
Air Force Reserve flight hours in support of NWS missions not included in totals



To support the line office requirements for flight hour demands, NOAA has evaluated the current fleet of research aircraft and begun to change the current mix. NOAA's aircraft are aging and many are in need of replacement or upgrade. Actions underway to maintain and renew the capabilities of NOAA aircraft include:

1) Bell 212 Helicopter N60RF was disposed of in FY02 due to underutilization. This aircraft is being replaced by a DHC-6 Twin Otter.

2) AC-690 Turbo Commander N53RF - funding approved in the FY04 President's Budget to replace this aircraft with a newer Turbo Commander.

3) Light Twin-Engine Helicopter - FY05 initiative being developed to purchase a new helicopter to replace the MD 500 single-engine helicopter N59RF, and the Bell 212 helicopter N61RF.

4) Citation Replacement/Upgrade - FY05 initiative being developed to purchase an improved replacement aircraft for the CE 500 Citation jet N52RF.

5) Adding another WP-3D aircraft to the fleet – Recommend taking possession of a P-3 already used for scientific research immediately. FY05 initiatives have been submitted for SDLM and O&M.

6) Long EZ – replacement with a Velocity aircraft proposed by NOAA's Office of Oceanic and Atmospheric Research (OAR).

Future recommendations for changes to the mix of aircraft include:

1) Adding another high-altitude jet to the aircraft fleet – FY06 initiative will be submitted.

2) Both Shrike Commanders are recommended for replacement in FY10 and FY11.

3) OAR is submitting a FY05 initiative for acquiring Global Hawk UAVs.

4) A P-3 replacement study is recommended to commence in FY10.

The detailed NOAA mission goals that require the use of aircraft are outlined in Chapter 2, followed by fleet replacement details and requested technology improvements. A synopsis of prior studies that were reviewed for this report is listed in Chapter 6. Finally, the report concludes with a summary of recommendations.

2.0 NOAA Missions, Data Requirements, and Aircraft Needs

NOAA's MISSION

To understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet the Nation's economic, social, and environmental needs.

NOAA's VISION

To move NOAA into the 21st Century scientifically and operationally, in the same interrelated manner as the environment that we observe and forecast, while recognizing the link between our global economy and our planet's environment.

The 2003 NOAA Strategic Plan identifies four overarching goals for achieving the agency's mission. This report describes and addresses each of those mission goals in the order in which NOAA airborne platforms provide the most operational support:

- Serve society's needs for weather and water information
- Understand climate variability and change to enhance society's ability to plan and respond
- Protect, restore, and manage the use of coastal and ocean resources through ecosystem management approaches
- Support the Nation's commerce with information for safe and efficient transportation

In an effort to build specific core strengths, NOAA has selected six core capabilities that it recognizes as essential to support its mission goals. The Aircraft Operations Center provides NOAA with airborne platform support for the following two cross-cutting priorities:

- Homeland Security
- Integrated Global Environmental Observation and Data Management System

2.1 Serving Society's Needs for Weather and Water Information

On average, hurricanes, tornadoes, and other severe weather events cause $11 billion in damages each year. Weather is directly linked to public safety and about one-third of the U.S. economy (about $3 trillion) is weather sensitive. With so much at stake, NOAA's role in observing, forecasting, and warning of environmental events is expanding, and economic sectors and its public are becoming increasingly sophisticated at using NOAA's weather, air quality, and water information to improve their operational efficiencies and their management of environmental resources, and quality of life.

2.1.1 Airborne data-collection requirements

NOAA routinely uses aircraft to collect data for hurricane research, reconnaissance, and surveillance missions; winter storm research; thunderstorm research; low-level jet research; and soil moisture and snow survey assessments. Additionally, NOAA collects post weather-damage- assessment data to categorize intensity of tornados, hurricanes, flooding, and other weather phenomena.

The meteorological data collected by NOAA aircraft are fed into climate and weather models to improve severe weather forecasts and warnings; understanding of storm dynamics; understanding and warnings of tornadoes and supercell thunderstorms; winter storm forecasts; hurricane track and intensity forecasts; and satellite retrieval algorithms for temperature, humidity, precipitation, and wind. Hydrological data are also collected for the NWS River Forecast Center's (RFC) snow melt flood forecasts and water supply forecasts. NOAA aircraft conduct calibration and validation flights for NOAA satellite sensors, including NOAA POES, DMSP, and NPOESS sensors, as well as for NOAA GOES microwave sensors development.

2.1.2 NOAA programs and initiatives requiring aircraft support

Storm Research (Hurricanes, Winter Storms, etc.)

The meteorology, oceanography, and air physics communities in NOAA's National Weather Service and NOAA's Office of Oceanic and Atmospheric Research defined nine mission profiles during the heavy aircraft workshop in July 2000 to address research and operational issues. Additionally, these topics are critically important to the successful achievement of the U.S. Weather Research Program (USWRP) objectives. Of the nine mission profiles identified, six address research problems and three address operational problems. These mission profiles can be placed in five categories:

1) Improvement of severe weather forecasts and warnings: designed to collect observations to improve understanding of storm dynamics and to improve understanding and warnings of tornadoes and supercell thunderstorms.

2) Improvement of winter storm forecasts: designed to collect dropsonde data over targeted regions of the Northeast Pacific. This mission is tied to the strategic goal to increase lead-time and probability of detection of winter storms over the continental U.S. and Alaska, as well as to provide West Coast forecasts as accurately as for the rest of the country.

3) Improvement of hurricane track and intensity forecasts: designed to collect observations to improve understanding and forecasts of hurricane tracks and hurricane intensity change. These missions are tied to the outcome measures to increase the average lead-time for hurricane landfalls and improve hurricane wind-speed forecasts.

4) Improvement of numerical weather prediction model representations of sub-grid scale effects: designed to collect observations to guide improved parameterization of radiative, cloud microphysical, and turbulent processes.

5) Improvement of satellite retrieval algorithms (microwave, short-wave, long-wave) for temperature, humidity, precipitation, and wind: designed to collect observations to calibrate and validate satellite remote-sensed retrievals. This mission includes satellite calibration and validation campaigns associated with NOAA POES, DMSP, and NPOESS sensors, as well as microwave sensors development for NOAA GOES.

Tropical Prediction Center (TPC) Requirements:
Current TPC requirements for aircraft support are outlined in the National Hurricane Operations Plan (NHOP), section 5.4. The present requirements include some that are not being met with current instrumentation, the most significant being the surface wind profile below the aircraft flight track. The SFMR is close to meeting this requirement, but it has not yet demonstrated the reliability and consistent accuracy needed to be considered a fully operational instrument. This instrument needs to be brought to the "operational" level.

Improved observations of the hurricane inner core will be required to improve the prediction of hurricane intensity. While the precise observations that will be needed are not well known, it is likely that the three-dimensional wind field in and immediately surrounding the core region will be a necessary input to the next generation of numerical models. This will include regions without precipitation scatterers. What is less clear is whether continuous profiles of temperature and moisture will be required. If so, this will likely need to be done with remote sensors, rather than with dropsondes, due to the cost of the expendables.

NHOP does not currently show a requirement for surface wave heights, but TPC does have a requirement to specify the extent of 12-foot seas surrounding a tropical cyclone at the advisory time. A variant of the Scanning Radar Altimeter could provide this information from the G-IV.

All flight profiles in the meteorology and air physics community require operating from the deep tropics to the poles, operating in remote regions requiring endurance greater than eight hours, operating in a "low and slow" flight mode, as well as operating with heavy payloads that often require modifications from mission to mission.

The Severe Clear Air Turbulence Colliding with Air Traffic Project (SCATCAT) is a NOAA/FAA study to seek out and forecast clear air turbulence. The project requires a high-altitude, long-range, dropwindsonde-capable jet capable of quickly deploying to target areas and remaining on station for long periods at high altitudes. The NOAA G-IV proved to be the perfect platform for this research. The aircraft's limited availability has greatly hampered continued project support flights. Program support has been limited to "piggyback" flights during winter storm missions.

NMAO has been requested to provide the jet to support several weather research projects. One example is The Observing System Research and Predictability Experiment (THORPEX). THORPEX is a 10-year international research program to accelerate improvements in short- and medium-range (three- to 10-day) predictions and warnings of high-impact weather over the Northern Hemisphere. Many large forecast errors still result from initial storm condition errors. Initial positions of synoptic trough and ridge systems over wide areas of the North Pacific Ocean can be in error by as much as several hundred miles on certain days, greatly impacting forecasts for the Northern Hemisphere. NOAA G-IV winter storm missions only provide data over the central and eastern north Pacific Ocean to assist in the short-range North American forecasts. The THORPEX project is designed to globally expand these capabilities. The G-IV aircraft has been requested to perform program flights but is severely limited because of the permanent operational commitments to the Hurricane Surveillance and Winter Storm Programs.

Snow Survey

NOHRSC has maintained an Airborne Gamma Radiation Snow Survey Program across the country for more than 20 years. The program uses NOAA's low-flying Turbo Commander and Shrike aircraft to make measurements of natural terrestrial gamma radiation emitted from the potassium, thorium, and uranium radioisotopes in the upper 20 cm of soil. A network of 2170 operational flight lines has been established covering portions of 31 states (including Alaska) and eight Canadian provinces. Airborne radiation data are collected by two aircraft simultaneously from January through April or May depending on snow cover conditions. Additionally, background radiation data on new flight lines and soil moisture surveys are conducted each year during the summer and fall, respectively. Data collected by the snow survey aircraft provide improvements in NWS River Forecast Center's (RFC) snow-melt-dependent forecasts (snow-melt flood forecasts and outlooks, and water-supply forecasts) of about six percent on a national level (*NWS Operational Requirements Document, 1999*).

NWS Aerial Survey and Transportation Needs

NWS requires aircraft to collect damage information following extreme events to assist in classifying the event and determining the track and intensity of tornados, severe thunderstorms, downbursts, flooding, and storm surge events. Aircraft are also needed for forecaster area orientation, aviation forecast flight operations familiarization, and electronic/systems maintenance personnel point-to-point transportation. These requirements exist nationwide with emphasis in NWS Southern, Western, Alaska and Pacific Regions for more rapid response to critical system outages as well as transportation to remote facility and equipment sites.

NWS uses chartered aircraft to fulfill its current aerial survey and transportation needs. Charter aircraft are more readily available on short notice and can be rented near the survey sites. Light- to medium-sized fixed-wing or helicopter aircraft (high-wing or rotor aircraft preferred for maximum visibility and to map/photograph surface damage swaths) are adequate to conduct quick-response aerial photographic surveys of ground damage after weather events. Data collected is done photographically with a digital camera linked to GIS for construction of accurate post event maps. Orientation, familiarization, and personnel transport flights are also handled by chartered light aircraft. FY03 NWS estimates were 555 hours and $67K in aircraft charters to support these requirements; 89 percent of the hours and 80 percent of the costs were for operations in Alaska.

2.1.3 Aircraft flight hour needs

Mission	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Weather & Water Impacts										
In-House	1660	1810	2465	2465	2660	2660	2660	2660	2660	2660
Air Force Reserve NWS Support*	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600
Charter	705	680	655	630	630	630	630	630	630	630
Unmet	220	770	195	195	0	0	0	0	0	0
Total	**2585**	**3260**	**3315**	**3290**	**3290**	**3290**	**3290**	**3290**	**3290**	**3290**

*** Note Air Force Reserve flight hours are not included in the totals**

FY03 In-House Hours Support: Hurricane Reconnaissance, Surveillance, and Research; Winter Storms, Ocean Winds, Bow-Echo and MCV Experiment (BAMEX), and Snow Survey.

Air Force Reserve – 53rd Weather Research Squadron

In addition to NOAA aircraft flight-hour requirements, NWS has a requirement (up to 1600 hours of heavy aircraft flight time) to acquire low-level hurricane reconnaissance data. Currently provided through Air Force Reserve reconnaissance flights, these data are vital for NOAA's model initialization, track, and intensity forecasts and will continue to be very important for the next 10 years

FY03 Charter Hours Support: Weather Service requirements for post-damage assessment flights, forecaster orientation, flight forecast familiarization, and transportation to remote sites for electronic system maintenance.

FY03 Unmet Requirements: Pacific Land-Falling Jets Experiment (PACJET), and some of the hours requested for BAMEX and Hurricane Research.

2.1.4 Current in-house capability assessment

G-IV SP	
Max Range	4000 NM
Max Endurance	10.3 hrs
Operational Speeds	Mach .76 - Mach .88
Service Ceiling	45,000'
Useful Payload	32,000lbs
Crew Complement (Pilots-Crew)	2-13

G-IV: The Gulfstream (G-IV) jet currently supports NOAA's National Hurricane Center (NHC)/Tropical Prediction Center's (TPC) synoptic surveillance mission and winter storm reconnaissance. This aircraft collects, processes, and transmits vertical atmospheric soundings in various weather conditions, including the environment of a hurricane. The principal tool used for this task is the GPS dropwindsonde. The dropwindsonde is released from the G-IV, measuring and transmitting back to the aircraft the pressure, temperature, humidity, and GPS Doppler frequency shifts as it descends to earth. The Doppler shifts are used to compute the horizontal and vertical wind components, which are then transmitted to NOAA's National Centers for Environmental Prediction (NCEP) and TPC for inclusion into the global and hurricane model runs. It has had success at reducing hurricane track errors from numerical models. However, it does not have sufficient range to cover all the areas surrounding a tropical cyclone that are of interest to TPC. As a result, TPC occasionally will task a second aircraft to fly concurrently with the G-IV to provide additional coverage. The preferred aircraft for this mission is the C-130J because of its range and ceiling advantages over the WP-3Ds. However, ideally this mission would be performed by two G-IVs or similar aircraft.

There is ongoing research at NOAA's Hurricane Research Division (HRD) to define the key regions that need to be sampled to improve forecasts from numerical models (targeted observations). This research is still at an early stage, however, and it may be quite some time before TPC is prepared to lower the range/aerial coverage requirements of the surveillance mission.

G-IV Current Instrumentation	
Meteorological	
Hurricane Analysis and Processing System	Workstation accomplishes data analysis, processing, and message formatting Airborne Atmospheric Sounding Processing Environment (ASPEN) for dropwindsonde data processing
Total Temperature	Deiced Platinum Wire Resistor- Rosemount 102CP2AF and 102LJ2AG w/510GB41E amp Non-deiced Platinum Wire Resistor - Rosemount 102CL2AZ w/510GB35E amp
Dew point temperature	Chilled Mirror Hygrometer - Edge Tech (EG&G) 137-C3 Hygrometer w/137-S100 Sensor Cryo Hygrometer
Meteorological and Atmospheric Sensor Output	Two Data System Modules for instrument interface and data collection with 6 Networked Workstations
Airborne Vertical Atmospheric Profiling	Dropwindsonde Data System for drop execution, data collection and storage, Dropwindsonde Launch Chute, GPS dropwindsondes
Weather Radar	Collins WXR-700C C-Band w/ 30-inch antenna
Radiation	
Sea surface temperature	IR Radiometer (9.5-11.5 um) - Pyrometer Model PRT-5 w/AOC control unit
CO2, air temperature	IR Radiometer (14-16 um) - Barnes Model PRT-5 w/AOC control unit
Navigation	
Position (Latitude, Longitude), Ground Speed	2 Independent Inertial Navigation Systems - Honeywell Laseref II YG1779B Channel GPS Precision (Y Code) - Rockwell Collins 59J-1 Receiver 2 Honeywell 12 channel GPS
Pitch, Roll, Heading	Wander Azmith Stable Platform Inertial Reference System - Honeywell Laseref II YG1779B
Static Pressure	Ps Transducer - Rosemount 1281AF2B1B
Dynamic Pressure	qc Transducer - Rosemount 1281AF2B1B
Angle of Attack Differential Pressure	Differential Pressure Transducer - Rosemount 1221F2VL7B1B
Sideslip Differential Pressure	Differential Pressure Transducer - Rosemount 1221F2VL7B1B
Angle of Attack Dynamic Pressure	Differential Pressure Transducer - Rosemount 1221F2AF8B1B
Sideslip Dynamic Pressure	Differential Pressure Transducer - Rosemount 1221F2AF8B1B
True Altitude	Radar Altimeter - Gould APN-232
Mean Sea Level Altitude	5 Channel GPS Precision (Y code) - Rockwell Receiver 3M
Communication	AF, VHF, UHF, ADF, Flight Phone, INMARSAT SATCOM and Passenger Communication System, Iridium SATCOM

WP-3D: NOAA operates two WP-3D Orion turboprop airplanes. According to NOAA's air physics and meteorological scientists participating in NOAA's Heavy Aircraft Workshop in July 2000, "They are able to accommodate the large suite of remote sensing and in-situ measurements that are required for investigating meteorological and atmospheric physics problems…from the meteorology and atmospheric physics perspective, there is no better alternative to the WP-3D platform. Additionally, given the significant and growing demands for WP-3D aircraft, use can severely limit aircraft availability at certain periods of time, such as hurricane season. Aircraft maintenance and repair can further complicate this situation. Our experience suggests that if only one WP-3D is in operation, limited WP-3D availability would probably produce an untenable situation for the NOAA research community."

WP-3D	
Max Range	3000 NM
Max Endurance	11.5 hrs
Operational Speeds	180-350 KIAS
Service Ceiling	30,000'
Useful Payload	58,000lbs
Crew Complement (Pilots-Crew)	4-20

WP-3D Current Instrumentation	
Meteorological	
State Variables	Sensors for the measurement of temperature, humidity, pressure, winds and fluxes
Cloud Particles	PMS 2-dimensional and 1-dimensional precipitation and cloud particle probes, PMS Forward and Axially scattering particle probes
	Aerosol sampling system
Radiation	Sea surface temperature radiometer
	CO_2 air temperature radiometer
	C-band and K_u-band scatterometers
	Eppley solar and terrestrial pyranometer and pyrgeometer radiometers
	Stepped frequency microwave radiometer
Airborne Vertical Atmospheric Profiling	Dropwindsonde data system for drop execution, data collection and storage; Dropwindsonde launch chute, GPS dropwindsondes
Sea Temp Profile	Airborne Expendable Bathythermographs (AXBT's) with 200-meter depth capability
Expandability	External wing store station mounts
Radar	
Weather Avoidance	Collins C-band nose radar
Horizontal	Lower fuselage C-band research radar – 360 deg. horizontal fan beam
Vertical	X-band Doppler tail research radar
Wind Flux	Radome flow angle sensors
Navigation	
Position Latitude, Longitude, Ground Speed	Dual INE and GPS navigation systems

AC-690A: The Gulfstream Turbo Commander (AC-690) is a high-winged, twin-engine, pressurized turboprop aircraft capable of flying at low speeds and altitudes. NOAA's Turbo Commander N53RF is scheduled for replacement in FY04. NOAA's National Operational Hydrologic Remote Sensing Center (NOHRSC) uses this aircraft in the West and in Alaska to conduct airborne snow and soil moisture surveys because it has the required performance capabilities for the higher elevations

AC-690A Turbo Commander	
Max Range	1000 NM
Max Endurance	6 hrs
Operational Speeds	120-250 KIAS
Service Ceiling	31,000'
Useful Payload	3,420lbs
Crew Complement (Pilots-Crew)	2-7

AC-500S: NOAA operates two Rockwell Shrike Aero Commanders. They are versatile, high-winged, twin piston-engine aircraft. N51RF primarily serves NOHRSC. NOHRSC uses the Aero Commander (500S) in the upper Midwest and in the East for snow survey and soil moisture surveys. The mission is flown at 500 feet above ground level and at 100-120 knots in survey configuration. The snow survey aircraft must be a twin-engine, high-wing (to ensure pilot visibility directly below) aircraft with no fuel bladders in the belly that will attenuate the terrestrial gamma radiation signal. The other Shrike is primarily used for airport surveys, remote sensing, and marine mammal assessments.

AC-500S Shrike Commander	
Max Range	860 NM
Max Endurance	4.5 hrs
Operational Speeds	90-160 KIAS
Service Ceiling	12,500' or 25,000 w/O_2
Useful Payload	1,450lbs
Crew Complement (Pilots-Crew)	2-7

2.1.5 Projected service life and replacement schedule of NOAA assets

Aircraft	Year Built	Mission Supported	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
WP-3D N42RF	1975	Weather/Water										
WP-3D N43RF	1976	Weather/Water										
Additional P-3		Weather/Water	Procure		SDLM and Instrument							
G-IVSP N49RF	1994	Weather/Water										
Additional High Altitude Jet		Weather/Water				Procure and Instrument						
Turbo Commander N53RF	1974	Weather/Water		Remove From Service and Replace								
Turbo CDR Replacement		Weather/Water		Replace N53RF (Funded)								
Shrike Commander N51RF	1977	Weather/Water									Replace	
Small Environmental Research Aircraft		Weather/Water	Procure and Instrument									

Aircraft Under 20 Years
Aircraft Between 20 and 30 Years
Aircraft Between 30 and 40 Years

2.1.6 Future aircraft platform requirements

Additional High-Altitude Jet

NOAA's high-altitude G-IV jet performs hurricane/tropical cyclone surveillance missions during the Atlantic/Pacific hurricane season. The hurricane season begins June 1 and ends November 30 each year. In addition, winter storm missions are conducted annually from January 1 until March 31. The aircraft has scheduled maintenance performed annually from April 1 to approximately May 10.

NMAO currently cannot support all requests from NWS and the atmospheric research community for G-IV support because of the operational requirements of the programs listed above. The addition of a second high-altitude, sonde-capable, jet would increase NOAA's ability to perform the present hurricane and winter storm missions and allow it to complete several additional operational and research missions in support of climate and weather services. The increased capability would significantly enhance NOAA's ability to understand and predict climate phenomena.

NHC/TPC has a requirement for increased hurricane surveillance coverage, both in geographic area and time to ensure data for both model runs. This removes any track vacillation that results from data for only one model run. Twenty-four hour operations, utilizing one NOAA G-IV jet during FY02, significantly improved track forecasts during Hurricanes Isidore and Lili. Further forecast improvements will be realized if the coverage area per model run and round-the-clock operations is increased.

The National Hurricane Center, in the interest of increased geographic coverage, in the past has tasked two aircraft (the G-IV and a WP-3D or C-130) to perform simultaneous surveillance missions. However, the turboprop aircraft cannot cover the same horizontal area in the required time or the same altitude as the jet, resulting in less surveillance coverage area per model run. The addition of another high-altitude jet will allow surveillance coverage of over 10,000 nautical miles horizontally and 45,000 (G-IV) to 51,000 (G-V) feet vertically per model run (twice every 24 hours). This capability will ensure complete coverage of all meteorological phenomena and steering currents that could affect the hurricane's track and will, therefore, greatly improve hurricane forecasts beyond the present 15-20 percent presently realized with the single high- altitude jet.

Single jet round-the-clock surveillance missions are presently limited geographically both from an aircraft range and crew staffing perspective. The jet must launch and recover from the same general geographic location to allow the crew going off duty to rest during the second crew's mission. Changing locations after every flight and "staying ahead of the storm" throughout the entire life of the hurricane is not possible because of off-crew rest and relocation problems. A second jet will allow for two aircraft performing 24-hour operations in two locations, thereby increasing surveillance area coverage and allowing for operations throughout the entire evolution of the storm.

Vertical profiles of hurricane core winds are the top priority for improving hurricane intensity forecasts. The National Hurricane Center has stated that the three-dimensional wind field in and immediately surrounding the core region will be a necessary input to the next generation forecast models. The National Center for Environmental Prediction believes that these measurements, from the highest altitude possible, are essential for model vortex initialization and that advances in intensity and precipitation forecasts depend on the use of a high-altitude, long-range jet for data acquisition.

NOAA's G-IV jet was purchased to support the hurricane surveillance mission and the intensity forecast mission. The surveillance and winter storm missions must be supported. The intensity forecast mission must also be supported and the acquisition of a second jet aircraft is necessary to support both efforts.

The Weather Research and Forecasting (WRF) numerical prediction models represent the next generation of forecast models. The WRF model program is intended to develop an advanced mesoscale forecast and assimilation system and to promote closer ties between research and operations. This model suite is being developed by NOAA, NASA, the National Science Foundation, and the military.

NWS has proposed that the NOAA G-IV support data collection for input and verification of the WRF next-generation forecast models. A prioritized list of measurement parameters was developed in the summer of 2002. A summary of the requirements includes:

1) Measurement of 3-dimensional wind fields in the storm environment and in clear air.
2) Measurement of atmospheric vertical moisture structure.
3) Measurement of atmospheric vertical temperature structure.
4) Measurement of rain/cloud particle characteristics and humidity.
5) Measurement of ocean wave heights. NHC has an operational requirement to specify the radius of 12-foot seas surrounding a tropical cyclone.

NMAO has requested funding to modify the current G-IV aircraft and develop instrumentation that would accomplish the requirements of the WRF model data collection and verification. Careful consideration should be given to the reality that modification, instrument development, flight and instrument testing, and actual mission flights **cannot** occur simultaneously with only the single high-altitude jet. The time commitment to hurricane surveillance and winter storms does not allow any significant time to accomplish these necessary steps.

Acquisition of an additional high-altitude jet would cost \$50 M – \$90 M for the aircraft and initial modifications. In addition, NMAO would require the following additional personnel: 3 NOAA Corps pilots, 1 GS maintenance technician, 2 GS flight meteorologists, and 5 GS engineering support personnel.

Additional WP-3D

NOAA's research community is requesting a third WP-3D that could be used in the summer and fall when NOAA's current WP-3Ds are tasked with hurricane work. Additionally, this additional P-3 could serve as a back-up to the existing two aircraft during the hurricane season if needed.

Turbo Commander Replacement

A $1.55M budget initiative was approved for the FY04 replacement of NOAA's aging Turbo Commander. NOAA's AC-690A Turbo Commander (1974) N53RF is one of the highest-hour Turbo Commander airframes in the world for its age, with nearly 12,000 hours of high-stress flight time on the airframe. The initiative will replace the current NOAA aircraft with a high-wing, multi-engine, turboprop platform modified with a camera port and the capability of extended-range fuel tanks to support NWS's Airborne Snow Survey Program.

Acquisition of a replacement Turbo Commander platform is a key component in NWS's effort to meet its goal to increase the accuracy and timeliness of Advanced Hydrologic Prediction Services (AHPS) forecasts and warnings across the conterminous U.S. and in Alaska. The NWS Airborne Snow Survey Program provides critical data to NWS Hydrologic Services Program that is used to improve AHPS river and flood forecasts, water supply forecasts, and spring flood outlooks.

Shrike Replacement

NOAA's Shrike Commander N51RF is recommended for replacement in FY11.

Small Environmental Research Aircraft (SERA)

NOAA's research community requires an environmentally friendly single-engine, two-four seat, operationally simple, light airplane instrumented to measure turbulence in-situ and surface-state parameters to support weather and climate studies and air chemistry research. This aircraft will replace the capabilities of a Long EZ experimental aircraft and instrumentation that was lost in an accident in August 2002.

2.1.7 Capability and Technology Enhancements

NOAA air physics and meteorological research and operational community scientists participating in the Heavy Aircraft Workshop in July 2000 identified airborne instrumentation enhancements required to support the nine mission profiles identified in Section 2.1.3 of this report. These requirements point to a need for high-frequency in-situ data sampling up to 40 Hertz (Hz), radiometer-based imaging of clouds, water vapor, and precipitation at high spatial resolution, and radar-based precipitation mapping around the aircraft either for weather avoidance or to choose precipitation targets for sampling. Besides these key instrument capabilities, many profiles require a varying array of in-situ and remote sensing instruments. The specific instrumentation requirements are:

- All profiles require in-situ state variables (pressure [P], temperature [T], humidity [H], east-west wind component [u], north-south wind component [v], vertical wind component [w], location, altitude) at data rates up to 40 Hz and available to other data systems via intraplane telecommunication.
- All profiles require in-situ cloud microphysics observations from a few micro-meters to 10 cm.
- All profiles require airborne radars to either map precipitation out to 100 nm from the aircraft or for weather avoidance.
- Many profiles require in-situ short-wave and long-wave radiation observations.
- Many profiles require three-dimensional mapping of precipitation and winds over short time intervals around the aircraft by a vertically scanning airborne Doppler radar.
- Many profiles require ability to launch expendables (GPS dropsondes and airborne expendable ocean probes, e.g., bathythermographs, current probes, and conductivity temperature and depth probes-AXBT, AXCP, AXCTD, respectively) to sample the atmosphere to the ocean surface, and to 200m below the ocean surface.
- Launch capability to deploy GPS dropsondes at rates up to one per minute.
- Many profiles require capability to carry a number of remote sensors (passive and active) at the same time in a suite (e.g., radiometers, scatterometers, LIDARs, interferometers).
- Both research and operational profiles require at least moderately high bandwidth communications with the ground (>9600 baud).

Environmental Technology Laboratory Requirements

The Environmental Technology Laboratory's Pacific Landfalling Jets Experiment (PACJET**)** requires 24-hour operations, double crew, improved onboard radar data processing, and better microphysics packages. Also needed are a double crew and/or second aircraft, new flight level data system, upgraded PMS microphysics probes (better resolution, faster electronics), new cutting-edge microphysics probes such as Nevzorov total water content sensors, photographic cloud particle imaging sensors, and a new microphysics data acquisition system that will be more reliable, faster, and allow easier access to data after a flight.

- Need an aircraft in summer and fall that is not tied to hurricanes
- Better radiometric observing capabilities for satellite cal/val
- WP-3D plus high-altitude dropsonde aircraft is ideal (another G-IV, or a leased aircraft)
- Regional, mesoscale targeted observations are a new area

Snow Survey Requirements

Installation and testing of a passive/active microwave sensor onboard the snow survey aircraft for use simultaneously with airborne gamma radiation data collection are required. Additionally, the airborne gamma radiation detection systems are rapidly becoming obsolete and will soon need replacement. The current airborne detection systems are more than 15 years old and require increasing maintenance and repair. Spare or replacement parts are difficult or impossible to procure. Modern gamma radiation detection system technology is more efficient, less time consuming to calibrate, more reliable, and more accurate. The two existing detection systems will need to be replaced within an estimated five years.

2.1.8 New ways of doing business

NOAA's Environmental Technology Laboratory's (ETL) field requirements are rapidly evolving toward the need for extended-duration platforms for remote sensing of evolving weather; e.g., flights at least one day, and perhaps several weeks, long. Instruments could be downsized and placed on, for example, the AeroVironment Helios solar-powered aircraft to suit many targeted weather observation purposes within this decade. Transition to such capabilities will allow unique and valuable observations of developing weather practically unattainable using either manned aircraft or satellites.

ETL's PACJET scientists envision Unmanned Aerial Vehicles (UAVs) as an area of critical testing and development, including a range of ambitious capabilities, up to airborne radar capabilities from a NEXRAD in the sky approach.

Remotely Piloted Vehicles (RPV's)

The National Severe Storms Laboratory (NSSL), in collaboration with Wyndemeere, Inc. and the University of Colorado in Boulder, is in the process of engineering a rapid-deployment airborne mesonet of Remotely Piloted Vehicles (RPVs). The ability of RPVs to operate at low speeds and low levels make them uniquely suited to studies of the structure and evolution of the pre-convective boundary layer and storms. Future mission profiles are being designed for studies of convective initiation in clear air, dynamical forcing mechanisms in the rear-flank downdraft region of supercell thunderstorms, and other related problems of high relevance to USWRP and NOAA goals.

NOAA's National Weather Service offices see the need for UAVs/RPVs equipped with high-resolution digital video cameras for future quick-response damage surveys after severe weather events, so the images can be viewed in real-time by damage teams on the ground.

2.2 Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Society exists in a highly variable climate system, with conditions changing over the span of seasons, years, decades, and longer. Weather- and climate-sensitive industries, both directly and indirectly, account for about one-third of the Nation's gross domestic product, or $3.0 trillion.
Seasonal and interannual variations in climate, like El Niño, led to economic impacts on the order of $25 billion for 1997-98, with property losses of over $2.5 billion and crop losses approaching $2.0 billion. Given such stresses as population growth, drought, and increasing demand for fresh water, it is essential for NOAA to provide reliable observations, forecasts, and assessments of climate, water, and ecosystems, as well as to participate in analyzing decisions to enhance decision makers' ability to minimize climate risks. This information will support decisions regarding community planning, public policy, business management, homeland security, and natural resource planning. In the U.S. agricultural sector alone, better forecasts can be worth over $300 million in avoided losses annually.

2.2.1 Airborne data collection requirements

Data requirements for air quality research and forecasting, global and regional climate change, and stratospheric ozone depletion are crucial to NOAA's ability to provide reliable observations, forecasts, and assessments of climate, water, and ecosystems, as well as to participate in analyzing decisions to enhance decision makers' ability to minimize climate risks. This information supports decisions regarding community planning, public policy, business management, homeland security, and natural resource planning.

2.2.2 NOAA programs and initiatives requiring aircraft support

Airborne Chemistry

Air chemistry and air physics research within NOAA require at least two heavy aircraft with medium- to long-range endurance and significant load-carrying capability. This is especially important for those missions requiring at least two airborne Doppler radars. In addition, air physics research within NOAA requires operational capability at altitudes from 30 meters to at least 12 kilometers above the surface. Most of the airborne mission profiles require low altitudes as well as slow operational speeds for measurements, parameters that are needs-conducive to the use of turboprop aircraft. Furthermore, most of the airborne mission profiles require an aircraft that can accommodate a large suite of remote-sensing and in-situ measurements.

The air chemistry research in NOAA's Office of Oceanic and Atmospheric Research (OAR) that requires the use of the NOAA heavy aircraft can be placed in three categories:

(1) air quality research and forecasting
(2) global and regional climate change
(3) stratospheric ozone depletion

Air quality research, which is typically done in the planetary boundary layer and the lower- to mid-free troposphere, requires an aircraft with medium- to long-range and significant load-carrying capacity that the WP-3Ds provide.

Global and regional climate change research is typically carried out in the free troposphere and lower stratosphere. The studies require long-range endurance and significant load-carrying capacity that are available with the WP-3D over the lower altitudes and G-IV at higher altitudes in the troposphere.

Aspects of the research that involve studies of deep convection in tropical regions and most stratospheric climate change and ozone depletion research will require an aircraft with operational altitude capabilities greater than that available in the NOAA fleet of heavy aircraft. Clearly, for this research during the next five years, we should seek cooperation with other agencies with the necessary aircraft capabilities.

NOAA's Pacific Marine Environmental Laboratory (PMEL) requires a WP-3D aircraft (or its equivalent) roughly once every three years for intensive field programs of air-sea interactions in the North Pacific, including the Bering Sea. It is possible that 24-hour operations would be required for some applications. The present suite of instrumentation aboard the WP-3Ds adequately handles the meteorological observations required; the oceanographic observations required consist of air-deployed expendables (AXBTs and AXCTDs). PMEL foresees increasing interest in doing oceanography from aircraft, and increasing interest in observing small-scale meteorological phenomena such as turbulence and cloud and precipitation microphysical phenomena.

Carbon Cycle Aircraft Soil Moisture and Flux Measurements

NOAA/OAR/Air Resources Laboratory requires aircraft support to collect carbon cycle research for the Climate Change Research Initiative (CCRI) established by President Bush. The CCRI is a multi-agency effort with a "strong focus on outcomes" and seeks to promote a "vision focused on the effective use of scientific knowledge in policy and management decisions."

The carbon cycle research of the past four decades has resulted in the identification of global CO_2 sources and sinks in the ocean and terrestrial biosphere and established the variability of these sinks in space and in time. These advances were possible because of the existence of the global CO_2 monitoring network and demonstrate the value of long-term monitoring. The research also demonstrated significant gaps in the scientific understanding of the carbon cycle, including large uncertainties in the size and location of both ocean and terrestrial CO_2 sinks and the need for better data assimilation and more accurate models.

Aircraft are now needed to make measurements of CO and CO_2 concentrations; of heat, momentum, and CO_2 fluxes; and of soil moisture using remote sensing techniques. OAR will participate in field programs to study the carbon cycle over terrestrial North America. These field programs will be coordinated through the U.S. Global Climate Change Research Program/Carbon Cycle Working Group and conducted in partnership with the NOAA Climate Monitoring and Diagnostics Laboratory (CMDL).

The measurements have four goals: 1) to extend local-scale observations to regional-scale flux estimates; 2) to relate vertical structures of CO_2 flux and concentration to boundary layer dynamics; 3) to relate CO_2 fluxes to variations in soil moisture and vegetation; and 4) to develop and validate measurement methods for satellite remote-sensing products.

The benefits to NOAA of this research are clarification of the mechanisms of the terrestrial carbon cycle; improved understanding of the relationships between surface vegetation and soil moisture and CO_2

fluxes; improved understanding of the relationship of vertical structures of CO_2 flux and concentration to boundary layer dynamics; development of more accurate models of the carbon cycle and better quantitative climate forecasts; identification and quantification of sources of natural variability in the terrestrial carbon cycle; and reduction of uncertainty in predicting the consequences of management scenarios.

2.2.3 Aircraft flight hour needs

Mission	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Climate Variability/Change										
In-House	175	450	655	655	655	655	655	655	655	655
Charter	100	100	100	125	100	100	100	100	100	100
Unmet	120	205	0	0	0	0	0	0	0	0
Total	**395**	**755**	**755**	**780**	**755**	**755**	**755**	**755**	**755**	**755**

FY03 In-House Hours Support: South American Low Level Jet (SALLJ), and Tracer Transport and Dispersion

FY03 Charter Hours Support: Ozone Study, and Air Pollution in the Troposphere

FY03 Unmet Requirements: Coastal Alaska Marine Processes (CAMP)

2.2.4 Current in-house capability assessment

G-IV: The Gulfstream IV (G-IV) currently supports the NOAA National Hurricane Center's synoptic surveillance mission and winter storm reconnaissance, and is capable of supporting climate variability studies.

WP-3D: NOAA operates two WP-3D Orions, which accommodate the large suite of remote- sensing and in-situ measurements that are required for investigating meteorological and atmospheric physics problems, as stated in section 2.1.4.

DHC-6: NOAA currently operates two Twin Otters, and due to the overwhelming demand for this platform, is in the process of procuring a third. The Twin Otter conducts atmospheric air chemistry sampling, and atmospheric eddy flux and concentration gradient assessments. This aircraft will be discussed in more detail in section 2.3 of this report.

2.2.5 Projected service life and replacement schedule of NOAA assets

Aircraft	Year Built	Mission Supported	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
WP-3D N42RF	1975	Climate Variability										
WP-3D N43RF	1976	Climate Variability										
Additional P-3		Climate Variability	Procure		SDLM and Instrument							
G-IVSP N49RF	1994	Climate Variability										
Additional High Altitude Jet		Climate Variability				Procure and Instrument						
Twin Otter N48RF	1981	Climate Variability										
Small Environmental Research Aircraft		Climate Variability	Procure and Instrument									
Global Hawk (UAV)		Climate Variability			Procure and Instrument							

Aircraft Under 20 Years
Aircraft Between 20 and 30 Years
Aircraft Between 30 and 40 Years

2.2.6 Future aircraft platform requirements

Additional WP-3D

Two WP-3Ds are required to satisfy NOAA's air chemistry requirements; however, in addition to the needs of the NOAA chemistry community, there are within NOAA significant additional demands for WP-3D time. Weather research and operations can severely limit aircraft availability at certain periods, and maintenance and repair periods can further complicate the situation. During non-hurricane season, air chemistry missions often require the availability of two WP-3Ds working together and the availability of only one produces an untenable situation for air chemistry research. In addition to aircraft availability, there is a need to easily replace the belly radars on the WP-3Ds with other NOAA sensors for air chemistry research, specifically the Polarimetric Scanning Radiometer series of imaging microwave radiometers and remote-sensing systems. NOAA is currently using the NASA WB-57F or a commercial Canberra B-6 to conduct some of this research requiring WP-3D capabilities with access to belly instrumentation, but the future of those assets is uncertain.

Since the NOAA Research community has a use for an aircraft with the capabilities of the NOAA WP-3D but with nadir view ports and a bomb bay or belly instrument pod, AOC suggests acquisition of another P-3. In addition to providing NOAA users with a P-3 with accessibility to belly instrumentation, the supplemental aircraft would be useable by all NOAA users during the hurricane season, would not be geographically committed to the Atlantic or Caribbean, and would ensure that two P-3s would be available during SDLM (standard depot level maintenance) years.

Additional High-Altitude Research Jet

The NOAA air chemistry research community has stated requirements for a high-altitude, long-range jet to support air quality research and forecasting, global and regional climate change, and atmospheric ozone depletion measurement. The high altitude, dropsonde capable, aircraft must be available for deployments throughout the year. NOAA research scientists have indicated that the dedication of NOAA airborne platforms to hurricane and winter storm missions significantly degrades their capability to perform air chemistry projects.

Small Environmental Research Aircraft (SERA)

The NOAA research community requires an environmentally friendly single-engine, two-four seat, operationally simple light airplane instrumented to measure turbulence in-situ and surface state parameters remotely to support climate studies and air chemistry research. The SERA must be capable of operation from any airport with at least 3000 ft of runway, however primitive or remote, and can operate at low airspeed and altitude (below 50 ms-1 within 30 m of ground).

In the past, low level atmospheric flux missions were conducted with a Long EZ experimental aircraft. Unfortunately, the Long EZ and instrumentation used by NOAA Research was lost in an accident in August 2002. Several missions are in jeopardy due to the loss of the instrumentation and platform. To fulfill the short-term requirement, contract aircraft will be chartered to support some of these missions in FY03. The planned 2003 URBAN study in Oklahoma City was envisioned using a SERA-type aircraft, requiring approximately 60-100 flight hours in Oklahoma City. Primary measurements include turbulence characterization, including measurement at 50 samples per second of CO2, H2O, air temperature, air pressure, and three-dimensional (3D) wind velocity. Surface characterization measurements, including surface temperature, laser altitude, and sensor position to one meter in 3D, are desirable. A proposed 2004 VTMX study with a SERA-type aircraft will require approximately 60-100 flight hours in Salt Lake City. Measurements are the same as above. Obtaining accurate positions (to 1 m) has increased importance, however, in this complex-terrain setting. A proposed 2006 URBAN study with a SERA-type aircraft will require approximately 60-100 flight hours. The same suite of measurements is required as above.

Other NOAA Air Resources Laboratory (ARL) programs also include Air Force and Office of Naval Research (ONR)-supported work. The reimbursable missions require high-frequency, extremely accurate wind/temperature and water vapor measurements from the surface to 20kft. In addition to pure fluxes, remote-sensing technology is used to determine sea state; this has included microwave scatterometers and range-finding high-PRT lasers. Ocean color and CO_2 measurements are also obtained for atmospheric research purposes. Over the past few years, ARL has operated the Long EZ roughly 200 hours per year in direct support of air chemistry programs, as well as instrument development and testing. The aircraft must be able to deploy off of primitive airfields with minimal ground support facilities. If the aircraft is configured correctly from the beginning, additional airframe modification should be minimal.

Extrapolating from current trends, the landscape of airborne measurements is expected to change dramatically in the next 10 years. Over the previous 10 years the Mobile Flux Platform (MFP) system has evolved beyond in-situ measurement of turbulent fluxes alone to include remote sensing of surface characteristics as well. Use of chemical sensors and remote sensing of the atmosphere for better application to computer models will increase. If upcoming initiatives to collaborate with the National Ocean Service and the U.S. Weather Research Program succeed, coordination between SERA aircraft and the NOAA Twin Otter will be required, especially in work involving air chemistry and linkages among soil moisture, evapotranspiration, and air-surface exchange.

Velocity XL RG

The acquisition of a Velocity airplane is currently under consideration to accommodate expanding atmospheric scientific measurement capabilities while retaining the characteristics noted above of an operationally simple small airplane.

In the longer term, the larger Velocity will fill a niche for an operationally simple small airplane, capable of carrying the turbulence and increased remote sensing beyond that pioneered on the Long-EZ. In certain circumstances involving only a few, easily installed instruments, rental aircraft will be more cost-effective. ARL seeks a three or four seat aircraft where two seats have been removed and replaced by instrumentation. The remaining two seats leave room for a pilot and flight scientist. Many of the instruments that are used in measuring the physical parameters of the atmosphere continue to get smaller, so in airborne applications weight and size continually become less of an issue. This is a unique capability that can only be filled by a smaller aircraft. NOAA Research is requesting NMAO to help acquire, maintain, and operate an aircraft to replace the Long-EZ.

Global Hawk UAV

NOAA atmospheric research scientists are exploring the concept of a new long-term global observing system to provide detailed profiles of the Earth's atmosphere and oceans. This system would use unmanned aerial vehicles (UAV's) in the lower stratosphere to launch dropwindsondes over a number of equally spaced, fixed locations over oceans and polar regions. The Global Hawk UAV will be discussed in more detail in section 2.6 of this report.

2.2.7 Capability and technology enhancements required

Ancillary Measurements

Several measurements were identified by the scientists participating in NOAA's Heavy Aircraft Workshop as needing to be included in any atmospheric chemistry study: accurate and fast-response water vapor measurements and an aerosol LIDAR. The water vapor measurement is important for both air chemistry and meteorological measurements. Although water vapor measurements are now being made routinely on the NOAA heavy aircraft, these measurements do not meet current research needs (precision, accuracy, and response time). Likewise, an aerosol LIDAR could provide information concerning the vertical structure of the atmosphere that would be vital to both air chemistry and meteorology research.

Additionally, the atmospheric chemistry community has requirements in one area where the present NOAA heavy aircraft fleet cannot satisfy current air chemistry research needs. This is research that requires an aircraft capable of carrying an integrated payload of measurements over longer distances and/or at higher altitude than is available with NOAA's current heavy aircraft. Atmospheric research and NOAA weather service operations also indicated the need for such an aircraft. Aircraft that could potentially meet these requirements are currently in the design and testing stage. These aircraft are primarily unmanned aerial vehicles (UAV's). The air chemistry community asked AOC to determine future NOAA research and operations needs in this regard and investigate the possibility of securing the use of such an aircraft, possibly through a cooperative arrangement with another agency.

Twin Otter Air Chemistry Upgrades

Twin Otter N48RF is extensively modified for NOAA Research-Air Resources Laboratory (ARL) needs. ARL plans to continue to use this platform and will require additional modifications throughout the next 10 years as technology develops. With the exception of a planned redesign of the external power bus to prevent periodic interruptions of scientific power during handoff from a ground power unit to aircraft generators, the following requests for modifications will require additional funding and are included in a FY05 budget initiative:

1) Modified wing hard points to allow the installation of laser spectrometers for real-time particle measurements. This modification would benefit all other users.

2) Acquisition of FSSP, PCASP, and 2 DC probes and installation of associated cabling throughout the aircraft wings.

3) Installation of the Best Aircraft Turbulence (BAT) probe on a boom on the nose of the aircraft. This instrument has been installed on the WP-3D, but installation on the Twin Otter will require additional engineering and fabrication support from NMAO.

Hard points will be added under one wing to provide mounting points for various Particle Measuring System (PMS) probes such as a Passive Cavity Aerosol Spectrometer Probe (PCASP) and a Forward Scattering Spectrometer Probe (FSSP). These instruments measure particle size and number based on light scattering properties. The PCASP measures particle diameters in 15 size bins ranging from 0.1 to 3 microns. The FSSP measures particles from 0.5 to 45 μm in diameter. In combination, these two instruments measure the range of particles important in aerosol and cloud physics research. Data from these probes will be important in ARL research programs that deal with air quality, visibility, wet and dry deposition, and radiative forcing and climate change. In addition to the PCASP and FFSP, the hard points will allow the mounting of a PMS OAP-2DC. This instrument provides two-dimensional shadows of particle shapes up to a few millimeters in diameter with 25 μm resolution. These measurements are important for studies of clouds.

Liquid or solid particles (aerosols) suspended in the air have important human health effects, particularly the particles in the size range under 2.5 μm, which are easily inhaled. As a result of epidemiological studies that have established a statistical connection between adverse health effects and $PM_{2.5}$, a new National Ambient Air Quality Standard (NAAQS) for these particles has been established. Ozone and $PM_{2.5}$ are formed by the same photochemical pathways and have the same precursors. Addition of the PCASP and FSSP to the suite of chemical measurements now made from the Twin Otter will complement current air quality capabilities. These measurements are essential to developing an understanding of the mechanisms of particle production and for assessing the effects of emissions management strategies.

Aerosols also have direct and indirect effects on the radiation balance of the earth. The direct effects occur because the particles scatter and absorb light. These effects depend on aerosol size distribution. Particles with diameters less than 1 μm scatter more light per unit mass than larger aerosols. The indirect effects occur because particles influence the formation and optical characteristics of clouds. Both effects are dependent on particle composition. The addition of the PCASP and FSSP probes to the suite of measurements presently available on the Twin Otter will provide critical information on the size spectra of aerosols that can be used in studying their radiative properties and the mechanisms of aerosol formation. This work includes comparing surface measurements with those made or inferred from other observing systems such as aircraft and satellites and modeling the radiative transfer process as a means of inferring the effects of clouds, aerosols and ozone on the transmission of visible and ultra-violet radiation.

The Best Aircraft Turbulence Probe (BAT) is an instrument roughly the size and shape of a baseball bat mounted in such a way as to extend the sensor head forward of the airplane's nose into a region of minimal flow disturbance. The BAT probe incorporates a pressure sphere housing with differential GPS (DGPS), solid-state sensors, and electronic and aerodynamic technology to allow high fidelity turbulence measurements from aircraft. The probe weighs 3 kg and requires 10 W of 10 to 30 VDC power. Typical studies include the determination of evaporation and the sensible heat flux from the Earth's surface (soil, vegetation, ocean and other water bodies) for land-use assessment or air-sea interaction processes, studies of the exchange of trace gases like CO2 between vegetation and the atmosphere in the context of studies of global change, as well as studies investigating mixing processes in the upper troposphere or between the troposphere and the stratosphere. Another example is studies of the structure of thermals and the three-dimensional wind field around them.

Benefits from air chemistry upgrade initiative:

- An increase in the data yield from individual air chemistry missions
- Particulate measurements that will yield better understanding of numerous physical and chemical atmospheric properties
- Atmospheric turbulence measurements that will provide data on numerous air-sea interaction processes, global climate change, and gas exchange within the atmosphere

2.2.8 New ways of doing business

The NOAA Aeronomy Laboratory is proposing to use the Global Hawk Unmanned Aerial Vehicle to make measurements related to the dynamical, chemical, and radiative properties near the tropical tropopause of the Pacific Ocean in a program titled the Global Hawk Tropical Tropopause Experiment. The proposed flights will take advantage of the large payload capacity, high cruise altitude, and long endurance of the Global Hawk and will demonstrate its value for atmospheric research. The payload instruments will provide in-situ measurements of total water, cirrus, aerosols, ozone, carbon dioxide, methane, pressure and temperature, and remote profiles of temperature. Four mission flights are planned for the Pacific Ocean basin from Dryden Flight Research Center (34°N). The flights rely on the ability of the Global Hawk to fly 11000 nm in flights up to 32 hours in duration. The flights will include long transects along the equator (7°N) and cross-equatorial transects extending into the extra-tropics (35°S) of the Southern Hemisphere. Both transects will be explored during northern winter and northern summer. The knowledge and insights gained with the acquired data set will address climate processes acting in the upper troposphere/lower stratosphere. Specific scientific issues to be addressed include particle production at the tropical tropopause, mixing between and within the upper troposphere and lower stratosphere, and scales of variability in the UT/LS. This unique data set should allow us to explore the existence of a circulation in the lower stratosphere that is the "mirror image" of the Walker circulation in the underlying troposphere. Additionally, gravity wave characterizations and transport modeling studies using the data collected will provide opportunities for increasing our understanding of transport processes in these under-sampled regions of the atmosphere.

2.3 Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem Management Approaches

Coastal areas are among the most developed in the Nation, with over half of our population residing within less than one-fifth of the land area in the contiguous U.S. Coastal counties are growing three times faster than counties elsewhere, adding more than 3,600 people a day to their populations. Coastal and marine waters support over 28 million jobs, generate over $54 billion in goods and services a year, and provide a tourism destination for 180 million Americans a year.

The value added to the national economy by the commercial fishing industry is over $28 billion annually, and about 18 million Americans engage in marine recreational fishing every year. Within this context NOAA works to achieve a balance between the use and protection of these resources to ensure their existence for future generations and their optimal contribution to the Nation's economy.

2.3.1 Airborne data-collection requirements

Collecting data for characterizing and managing coastal ecosystems, monitoring and assessing protected and endangered species, and rebuilding and maintaining sustainable fisheries is crucial to NOAA's

mission to conserve and manage coastal and marine resources to meet the Nation's economic, social, and environmental needs.

NOAA routinely uses aircraft to conduct marine mammal and endangered species surveys, manage and characterize NOAA's National Marine Sanctuaries, manage and assess the condition of fisheries stocks, manage wetlands restoration pro-jects, and assess the health of coastal ecosystems. Aircraft also are fast-response vehicles to assess oil spill and vessel groundings

2.3.2 NOAA programs and initiatives requiring aircraft support

NOS prepared a report in FY02 entitled*, Aircraft Needs and Opportunities for Use within the National Marine Sanctuary Program*, in which common needs were identified:

1) Enforcement of Areas to Be Avoided (ATBA), Marine Protected Areas (MPA), and fisheries statutes
2) Surveillance
3) Biological surveys (mammals and sea birds)
4) Oil spill and vessel grounding rapid response and assessment
5) MPA and visitor use quantification
6) Mapping
7) Remote sensing – characterization of reefs and associated habitats
8) Flying the flag (maintaining a visible NOAA presence)
9) Education and outreach

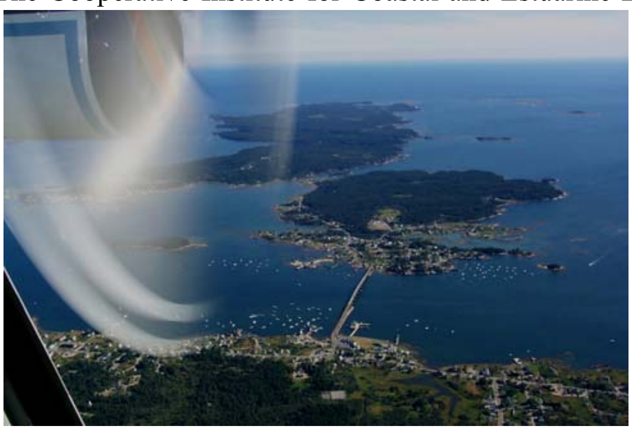
Historically, many of the NMS needs for enforcement, surveillance, and transportation were covered by opportunistic flights on U.S. Coast Guard aircraft. With the USCG's new focus on homeland security, the opportunistic flights for NOAA's needs have been greatly diminished. In addition to all of the management needs listed above, the sanctuaries need safe, efficient, and reliable transportation to access areas of responsibility. Another important consideration regarding some of the sanctuaries is their remote locations. The Flower Garden Banks National Marine Sanctuary is more than 100 miles offshore, which makes enforcement and surveillance difficult.

The Northwest Hawaiian Islands Coral Reef Ecosystem Reserve (NWHICRER) is one of the most remote areas in the Pacific. An enormous area, it encompasses the marine waters and submerged lands of the Northwestern Hawaiian Islands, extending approximately 1200 nautical miles long and 100 nautical miles wide. The

Reserve is currently developing a management plan as the first step toward designation as a National Marine Sanctuary. As such, it is imperative that the reserve manager and staff be able to access the site and characterize the resources of the Reserve.

NOAA coastal resource managers require small aircraft to visually inspect and photograph watersheds and wetlands under study to verify satellite imagery of land cover characterization. Most of this work is outsourced.

The Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) has funded a few projects over the past few years to develop airborne remote sensing technology applications (e.g. hyperspectral imaging). The reserve system is currently considering how to best use remote sensing to monitor land cover. Reserve managers have just completed a needs assessment that has identified issues in the reserves that can be addressed concerning remote sensing and GIS technologies. The data needs include mapping of upland and benthic habitats and information on bathymetry/topo-graphy. There is also an interest in using LIDAR for collecting elevation data.



The National Centers for Coastal Ocean Science (NCCOS) and Center for Coastal Fisheries and Habitat Research (CCFHR) currently fly LIDAR and SEAWIFS sensors over estuaries and near shore environments.

Airborne Estuary Flux and Salinity Measurements

Aircraft are needed to measure the atmospheric concentration of nitrogen and speciated mercury compounds; to use remote sensing to measure critical parameters of the water, including surface color, salinity, and temperature; to develop techniques and algorithms that can be applied to similar measurements from satellites; to measure critical water-

atmosphere-biosphere interactions, including air surface exchange of mercury and nitrogen compounds; to provide the data necessary to develop research and operational models for prediction of the effects of mitigation strategies; and to establish a mechanism to incorporate research results into operational tools.

Coastal ecosystems are subjected to a number of anthropogenic stresses. The causes of these stresses range from concentration of mercury in fish and shellfish to nutrient enrichment that can result in eutrophication and harmful algal blooms. It is estimated that 20 to 40 percent of the nitrogen entering coastal waters, such as the Chesapeake Bay, comes directly from the atmosphere. The portion of mercury entering these waters from the atmosphere is almost certainly greater than 90 percent. This initiative is for resources to develop the tools necessary to identify and quantify the sources and mechanisms that result in the deposition of mercury and nitrogen to coastal waters. This knowledge will be used to develop models that will help predict the effects of mitigation strategies on the health of these ecosystems.

The benefits of these data to NOAA include clarification of the physics of the mechanisms of atmospheric deposition to coastal waters; better characterization of the spatial and temporal distribution of these processes; improved understanding of the relationship between atmospheric and ecosystem health; development of more accurate models of the deposition of nutrients and toxic substances to coastal waters; and development of remote sensing tools that can be used globally.

The Marine Mammal Protection Act of 1972 (MMPA) was most recently reauthorized in 1994. In passing the MMPA in 1972, Congress found that:

- certain species and population stocks of marine mammals are, or may be, in danger of extinction or depletion as a result of man's activities
- such species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population level
- measures should be taken immediately to replenish any species or population stock which has diminished below its optimum sustainable level
- there is inadequate knowledge of the ecology and population dynamics of such marine mammals and of the factors which bear upon their ability to reproduce themselves successfully; and
- marine mammals have proven themselves to be resources of great international significance, aesthetic and recreational as well as economic

Aircraft are needed by NOAA Fisheries to monitor and assess large geographical areas quickly and economically. NOAA uses in-house resources as well as a significant amount of outsourcing to monitor marine species. Estimates for NMFS aircraft charters in FY03 total 1655 hours and over $700,000.

In the 1950s, fishermen discovered that yellow fin tuna in the Eastern Tropical Pacific (ETP) aggregated beneath schools of dolphin. Since that discovery, the predominant tuna fishing method in the ETP has been to encircle schools of dolphins with a fishing net to capture the tuna concentrated below. Hundreds of thousands of dolphins died in the early years of this fishery. U.S. participation in the ETP tuna fishery has greatly decreased over the years, coming to a virtual standstill by the early 1980s. However, foreign participation in the ETP fishery has continued to increase. In recent decades, the Marine Mammal Protection Act, improved fishing techniques, and international cooperation have resulted in greatly reduced dolphin mortality in the tuna purse seine fishery in the ETP. NOAA monitors the health of the dolphin stocks for dolphin conservation and ecosystem management in the ETP by conducting surveys utilizing the NOAA Ship DAVID STARR JORDAN, which is a helicopter-capable ship. The helicopter is used to photograph schools of dolphin for analysis and calibration of the observers aboard the ship.

2.3.3 Aircraft flight-hour needs

Mission	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Coastal/Ecosystem										
In-House	2030	2365	2415	2365	2415	2365	2415	2365	2415	2365
Charter	2075	2600	2600	2600	2600	2600	2600	2600	2600	2600
Unmet	750	0	0	0	0	0	0	0	0	0
Total	**4855**	**4965**	**5015**	**4965**	**5015**	**4965**	**5015**	**4965**	**5015**	**4965**

FY03 In-House Hours Support: Alaska Cetacean, ETP Dolphin, Harbor Porpoise, Mid Atlantic Tursiops Survey, Right Whales, Laser Vegetation Imaging Sensor Research, Channel Islands NMS Support, Estuarine Habitat, Flower Garden Banks NMS, Grays Reef NMS, Synthetic Aperture Radar Pod, USACE Everglades restoration, and IR Pod.

FY03 Charter Hours Support: Right Whales, Hawaii Humpback Whale NMS, Northwest Hawaiian Islands Coral Reef Ecosystem Reserve, Gray Whales, Harbor and Grey Seals, Beluga Whales, Tern Island and French Frigate Shoals support, Treaty and Tribal visits, Pacific Salmon Commission passenger transportation, Prince William Sound LIDAR, Navassa Island Coral Reef Assessment, Sea Lion Prey, Research Station transportation, Salmon Genetics and Nutritional Ecology, Shoreline Assessment, Pristane Monitoring, San Miguel Island, Winter Run Chinook, Land Cover Analysis, Pribilof Island, CWPPRA, Pinniped surveys, and Steller Sea Lion surveys.

FY03 Unmet Requirements: Some of the hours requested for Estuarine Habitat, Olympic Coast NMS, and Flower Gardens NMS, and all of the hours requested for Florida Keys NMS.

2.3.4 Current in-house capability assessment

DHC-6: The DeHavilland Twin Otter is a high-wing, twin turboprop airplane that is extremely versatile, highly maneuverable, and can be flown at low airspeeds. NOAA currently operates two Twin Otters, and due to the overwhelming demand for this platform, is in the process of procuring a third. This aircraft is the platform of choice for marine mammal surveys due to its high-wing design, clear visibility to track lines directly beneath the aircraft, and spacious cabin. The combination of its rugged "bush plane" construction, turbine reliability, and high-wing design make the Twin Otter perfectly suited for a wide range of scientific missions. Due to its unpressurized design, the Twin Otter can be modified to suit individual projects relatively quickly and inexpensively. The Twin Otter conducts low-level, slow-speed aerial surveys of marine mammals for NMFS, aerial video surveys of coastal erosion, a wide range of LIDAR missions, airborne topographical mapping, and multi-spectral scanning projects.

DHC-6 Twin Otter	
Max Range	840 NM
Max Endurance	7.5 hrs
Operational Speeds	80-160 KIAS
Service Ceiling	12,500' or 25,000 w/O_2
Useful Payload	4,400lbs
Crew Complement (Pilots-Crew)	2-8

CE-550: The Cessna Citation is a highly modified twin-engine jet aircraft. The Citation conducts remote sensing research, coral reef mapping, and environmental photography. The capabilities of the Citation will be discussed in more detail in section 2.4 of this report.

AC-500: NOAA operates two Rockwell Aero Commanders (AC-500S). This type of aircraft is a versatile and stable, high-winged, twin piston-engine aircraft that is suitable for a variety of missions. The aircraft has been used in biological investigations, such as algal bloom measurements and marine mammal and sea turtle population assessments.

Bell 212: The Bell 212 helicopter is extremely versatile in mission profile and operational parameters. NOAA's Bell 212 helicopter has provided logistical support for environmental studies and supported a variety of scientific missions, including Florida Everglades aerial surveys, base camp relocations in the Arctic, polar bear tracking/tagging, coastline surveys, oil spill damage assessments, and low-level survey work.

B- 212 Helicopter	
Max Range	375 NM
Max Endurance	3.5 hrs
Operational Speeds	hover - 120 KIAS
Service Ceiling	12,500'
Useful Payload	4,000lbs
Crew Complement (Pilots-Crew)	1-15

MD-500 Helicopter	
Max Range	300 NM
Max Endurance	2.8 hrs
Operational Speeds	hover - 156 KIAS
Service Ceiling	12,500'
Useful Payload	1,450lbs
Crew Complement (Pilots-Crew)	1-4

MD-500: NOAA's MD500 helicopter has been used to assess oil spill damage, survey coastal erosion, and survey marine mammals via vertical aerial photography. It is the only airframe currently capable of operating off of the NOAA Ship DAVID STARR JORDAN. The MD 500's small size, speed, and economy of use are its strong points for shipboard operations. However, because of its single-engine status, it is not the preferred platform to operate over water or in remote areas. When operating at sea level in hot climates, with three personnel and project equipment plus the added fixed floats, the power limits of the installed engine are pushed. Even with a power upgrade, given the tasking and warm weather environment in which the aircraft will be operated aboard ship, performance is always marginal.

LA-27: NOAA maintains two single-engine amphibious aircraft, one located at MacDill AFB in Tampa, FL, and one located in Santa Barbara, CA, which supports the Office of National Marine Sanctuaries. Currently, NOAA program requirements for small, single-engine amphibious aircraft do not justify keeping these two platforms. NMAO has received permission from GSA to dispose of the Lake aircraft presently based in Tampa. While the other Lake is dedicated to the Channel Islands National Marine Sanctuary (CINMS) throughout each fiscal year to respond to environmental emergencies, that program historically uses the aircraft an average of 60 days a year for 100-150 hours. Additionally, safety concerns dictate that the aircraft should not be flown more than 25 miles from land. NMAO would like to dispose of that aircraft as well and work with the program to support their needs through a combination of dedicated time on the NOAA Shrike Commander N47RF, contract aircraft, and partnerships with other state and federal agencies. In addition to supporting the CINMS, the Shrike Commander would be capable of safely and efficiently supporting all West Coast sanctuary near-shore (within 50 nm of the shoreline) light aircraft requirements. NOAA Fisheries would also benefit from a NOAA platform dedicated to the West Coast through the annual scheduling process. The cost of transit to the West Coast could be mitigated by scheduling Flight Edit missions to coincide with seasonal NOAA usage of the platform on the West Coast. Operation and utilization of the Shrike Commander could be assessed over a three-year period

(FY04-FY07) to determine if a permanent deployment to the West Coast would be of cost benefit to NOAA.

The Channel Islands National Marine Sanctuary, utilizing the dedicated Lake aircraft, developed SAMSAP (Sanctuary Aerial Monitoring Spatial Analysis Program), a GPS Visual Basic data-logging system that captures many of the parameters of common interest to the sanctuaries. This system is transportable to other aircraft for characterizing sanctuary resources.

LA-27 Lake	
Max Range	1,500 NM
Max Endurance	8 hrs
Operational Speeds	135 KIAS
Service Ceiling	12,500'
Useful Payload	1,450lbs
Crew Complement (Pilots-Crew)	1-4

2.3.5 Projected service life and replacement schedule of NOAA assets

Aircraft	Year Built	Mission Supported	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Citation II N52RF	1978	Coastal/Ecosystem					Remove from Service & Replace					
Citation Replacement		Coastal/Ecosystem				Replace N52RF						
Twin Otter N48RF	1981	Coastal/Ecosystem										
Twin Otter N57RF	1980	Coastal/Ecosystem										
Additional Twin Otter		Coastal/Ecosystem	Procure and Instrument									
Shrike CDR N47RF	1975	Coastal/Ecosystem								Replace		
Bell 212 N61RF	1979	Coastal/Ecosystem			Remove from Service and Replace							
MD-369 (500) N59RF	1979	Coastal/Ecosystem			Remove from Service and Replace							
Bell 212 & MD 369 Replacement		Coastal/Ecosystem			Replace N61RF & N59RF							
Lake LA-27 N64RF	1991	Coastal/Ecosystem		Remove From Service								
Lake LA-27 N65RF	1991	Coastal/Ecosystem	Remove from Service									
Small Environmental Research Aircraft		Coastal/Ecosystem	Procure and Instrument									

Aircraft Under 20 Years
Aircraft Between 20 and 30 Years
Aircraft Between 30 and 40 Years

2.3.6 Future aircraft platform requirements

Citation Replacement

A budget initiative will be submitted in FY06 to replace the aging Citation aircraft.

Additional NOAA-operated Twin Otter

NOAA Fisheries has extensive need for high-wing, twin-engine aircraft that can provide full trackline visibility for surveys of greater than six hours off of all CONUS coasts and Alaska, as well as over land. In all cases, the scientists have indicated that the NOAA Twin Otters are excellent platforms for research that requires scientific observations, use of remote-sensing instrumentation, or use of air sampling technology. The scientists are asking that the platform be capable of carrying up to seven scientists or equivalent payload of equipment and safely flying at low altitudes and airspeeds. Based on input from all NOAA line offices during the NOAA Light Aircraft Forum in November 2001, NMAO has determined that the two existing Twin Otters have not been meeting all requirements for a NOAA-operated versatile, fixed-wing light aircraft for many years. A Bell 212 helicopter was disposed of in FY02 and funds from that transaction are being applied to the purchase of an additional Twin Otter in FY03. The procurement for that platform is currently going through the solicitation process with the expectation of acquisition on or about March 2003. NMAO plans to select a Twin Otter that is capable of immediately supporting marine mammal surveys, and will upgrade aircraft power and modify it to support remote-sensing applications as time and funding are made available.

Shrike Replacement

Shrike N47RF is recommended for replacement in FY10.

Twin-engine Helicopter for Shipboard Operations

NOAA National Marine Fisheries Service scientists have requested an upgrade of the single-engine MD-500 helicopter to a twin-engine helicopter that would be compatible with the NOAA Ship DAVID STARR JORDAN (or replacement ship) and capable of conducting photogrammetry for marine mammal surveys. The MD 500 is not the preferred platform for reasons stated in section 2.3.4.

Conversely, the NOAA Bell 212 is an all-around utility helicopter that can fulfill an array of missions. Its strong points are its internal and external load capacities. The dual engine and redundant aircraft systems are important safety features. However, drawbacks include a large rotor footprint, excessive rotor noise, greater fuel use of a medium twin-engine helicopter, and maximum gross weight exceeding the capabilities of the NOAA Ship DAVID STARR JORDAN. In addition, Bell no longer produces this model of helicopter. Most have been sold to overseas operators by U.S. operators who have upgraded to the Bell 412. The NOAA Bell 212 is a base model and has received only minimal upgrades.

NMAO addresses this issue from the ship-side perspective in its November 2002 *Report of NOAA's Ship Platform Requirements for the Ten-Year Period from FY 2003 - FY 2012*. The report states:

> "Helicopter capable - NMFS currently uses the helicopter capability of the DAVID STARR JORDAN for marine mammal assessments. Replacing the MD-500 single-engine helicopter with a small twin-engine helicopter is anticipated. This will provide a greater safety margin for scientists and helicopter crew while working offshore. Future vessel design should allow for a larger helicopter and greater aviation fuel storage capacity than is currently on DAVID STARR JORDAN.

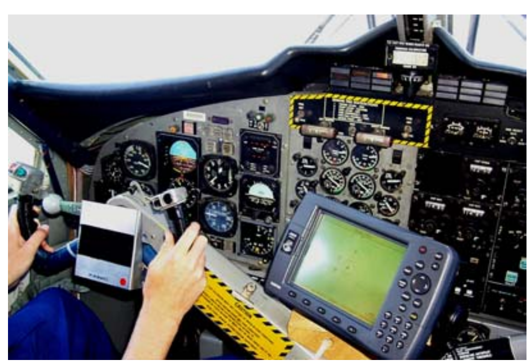
NMAO recommends replacing both helicopters with a light twin turbine helicopter that is lighter than the Bell 212 and more fuel efficient. An example of the type of platform that could replace both NOAA helicopters is the MD Explorer. Composite materials, smaller avionics, more powerful and efficient engines allow these newer aircraft to perform missions that in the past would only be possible with a much larger aircraft. Most of the newer helicopters incorporate increased safety features such as crashworthy seats for crew and passengers, crashworthy fuel systems, redundant drive systems, and in the case of the MD explorer, no tail rotor blades. The absence of tail rotor blades increases safety for personnel working around the operating aircraft when it is on the ground or flight deck of a ship. Power available in these newer aircraft is perhaps the most noteworthy enhancement. The MD Explorer can fly away from a single engine failure on the remaining engine at sea level at max gross weight. In a utility configuration, these helicopters have been designed for total access and have multiple mounting points internally and externally for customer equipment. In addition, the MD Explorer has large windows for superior observation, or can be flown with the doors open or removed for even greater visibility. These aircraft have high reliability as a result of new technology and design. Maintainability is streamlined for worldwide capability.

Small Environmental Research Aircraft (SERA)

NOAA Research is proposing to replace the Long-EZ experimental aircraft that was lost in an accident in FY02 with a single-engine, two-four seat, operationally simple light airplane instrumented to measure turbulence in-situ and surface state parameters to support climate studies and air chemistry research, ocean color, and CO_2 measurements.

2.3.7 Capability and technology enhancements required

Twin Otter Upgrades



NOAA's first Twin Otter entered service for the nation in 1985 and the second, nearly identical aircraft entered service in 1992. These aircraft were not identically configured, and both have subsequently received different specific airframe modifications, avionics upgrades, and scientific power distribution layouts to accommodate and support NOAA's research missions. However, each still has many unique features and peculiarities which make them less than completely interchangeable. NOAA was authorized to acquire a third Twin Otter in 2003, which will also have to undergo some level of modification to accommodate the existing data acquisition systems and cabin configurations required to conduct NOAA missions. These standardizations and upgrades are detailed in Chapter 5 of this report.

2.3.8 New ways of doing business

NOAA's Pacific Marine Environmental Laboratory (PMEL) is interested in the continued development of LIDARs for biological applications (e.g., fish detection) and remotely-based surface salinity sensors.

The Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve is interested in new and emerging technologies like hyperspectral imaging, LIDAR, and laser line scanning to better identify, characterize, map, understand, and manage the resources of the site. Specifically, the Reserve is interested in using hyperspectral imaging to develop maps that overlay habitat with habitat use, to use as exhibits and decision-making tools for identifying potential Marine Protected Areas within the Reserve. They would like to develop coral reef mosaics to identify places where they would not want people to go or to use. The NOS Biogeography Team is already doing some of this work. Currently, the best remote images of the Reserve are of four-meter resolution from the commercially available Ikonos satellite. The Reserve would like to use hyperspectral imaging to identify specific coral formations and then ground-truth those areas by scuba diving.

2.4 Support the Nation's Commerce with Information for Safe and Efficient Transportation

NOAA's information products and services are essential to the safe and efficient transport of goods and people at sea, in the air, and on land. As U.S. dependence on the Marine Transportation System (MTS) grows over the next 20 years with the projected doubling of the volume of maritime trade, better navigation and weather information will be critical to protect lives, cargo, and the environment. Reducing the risk of marine accidents and oil spills, better search and rescue capabilities, and other efficiencies that can be derived from improved navigation and coastal and ocean information and services could be worth over $300 million annually around the Nation's coasts. Improvements in NOAA's positioning and weather information will also support surface transportation safety and just-in-time efficiencies.

2.4.1 Airborne data collection requirements

Data collected for NOAA's shoreline collection, shallow water hydrographic surveys, and continued support of surveys near airports are crucial to the Nation's transportation system. Improvements in NOAA's positioning information will support surface and air transportation safety and just-in-time efficiencies.

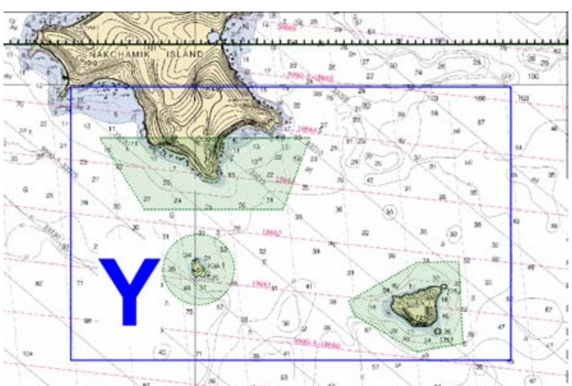
NOAA conducts aerial photography surveys near airports in the United States and its possessions in order to position obstructions and aids to air travel. NOAA maps the coastal regions of the United States and its possessions to position shorelines and other features needed to construct navigational charts using imagery. NOAA provides leadership in the development of standards and specifications for conducting geodetic surveys; coordinates the development and application of new surveying instrumentation and procedures; and conducts outreach activities including technical workshops held throughout the United

States and an advisory program maintained with 26 states. The goals are to achieve world-class leadership in the use of innovative techniques and application of geodetic science, remote sensing, and precise positioning.

NOAA conducts this work under the Coast and Geodetic Survey Act of 1947, 33 U.S.C. 883a, Executive Orders 11490 (1969) and 10480 (order addresses emergency preparedness), and the Hydrographic Services Improvement Act of 1998, 33 U.S.C. 892, 892a-892d.

The Remote Sensing Division (RSD) is a division within NOAA's National Geodetic Survey (NGS) that plans, coordinates, monitors, and provides technical direction for all NGS programs and activities requiring the use of aerial photographs and remotely sensed data. In the past, NGS has acquired its own aerial photographs and remote-sensing data, or it utilizes other conventional and non-conventional source material as required. Through photo-interpretation and photogrammetric mensuration, NGS compiles shoreline data, aids and hazards to navigation, landmarks, and other natural and manmade features critical to the generation of NOAA products. These data are disseminated in the form of digital data files, digital imagery files, and graphic and textural products. NGS prepares and approves standards and specifications for photogrammetric products. This Division collaborates with other NOAA components and other agencies in the application of aerial photography and other data acquired with airborne or space sensors. NGS supports research and development to increase the effectiveness and broaden the application of photogrammetry and remote sensing technologies in the interest of providing coastal zone and aeronautical information, meeting a broad spectrum of user requirements.

2.4.2 NOAA programs and initiatives requiring aircraft support



NOAA's Shoreline Mapping Program is to survey the nation's coastal regions to provide an accurate, consistent, and up-to-date national shoreline, a critical component in NOAA's nautical charts. The national shoreline provides the critical baseline data for demarcating America's marine territorial limits, including its Exclusive Economic Zone, and for the geographic reference needed to manage coastal resources and many other uses. These shoreline data are considered authoritative when determining the official shoreline for the United States. This program is administered by NGS and funded through NOAA's mapping and charting budget line item.

The United States has approximately 95,000 miles of coastline. Areas of photogrammetric responsibility include all coastal regions of the United States and its possessions, including the Great Lakes and their connecting navigable waterways. The shoreline depicted on NOAA's nautical charts approximates the line where the average high tide, known as Mean High Water

(MHW), intersects the coast. NOAA's shoreline mapping also provides the line where Mean Lower Low Water (MLLW) intersects the coast.

Until recently, acceptance of NOAA's shoreline data as a legal authority has been based upon NOAA's recognized expertise and court cases. Today, public law passed by the U.S. Congress in 1998 provides NOAA with explicit authority to promulgate national standards for all information acquired for nautical charting purposes.

The current methodology to delineate the shoreline is stereo photogrammetry using tide-coordinated aerial photography controlled by kinematic Global Positioning System (GPS) techniques. This process produces a seamless, digital database of the national shoreline and a database of aerial photography. The primary aerial photographic product is a 9x9 inch color photograph that is usually exposed at scales from 1:10,000 to 1:50,000 (flown at 5,000 to 25,000 feet, above ground level), varying slightly due to such factors as shrinkage or expansion of the paper caused by atmospheric conditions, accuracy of reported flight altitude, tip and tilt of the aircraft, and the effect of ground relief.

To maintain expertise in Coastal Mapping techniques and production, NGS will continue to collect **20 percent** of the total amount of shoreline requirements collected in a year as shown in Table 2.4.2.1.

The acquired shoreline data for the major ports and harbors, totaling 7,957 miles, will be collected on a five-year cycle; the national shoreline, including Alaska and the Pacific Islands, consisting of 87,043 miles of shoreline, will be collected on a ten-year cycle.

Table 2.4.2.1

Area	Miles of Coastline (NM)	Collection Cycle (YRS)	Miles of Data Acquired/ Year (NM)	Contracted/ Year (NM)	In-House Collection/Year (NM)
CONUS/Pacific Islands	54,000	10	5400	4320	1080
Alaska Coast	33,000	10	3300	2640	660
Major Ports	8,000	5	1600	1280	320

Data requirements for NOAA's shoreline are detailed in the Office of Coast Survey's *National Survey Plan* (November 2000).

The Airport Survey Program is to provide information to the Federal Aviation Administration (FAA) needed to ensure safe air transportation. NGS, in accordance with interagency agreements, provides the FAA with information needed for safe air transportation. This includes latitude, longitude, height, and orientation information for airport runways, taxiways, and navigational aids. The program is funded through a reimbursable agreement with the FAA.

To maintain expertise in Airport Survey techniques and production, NGS will continue to collect **20 percent** of the total amount of airport requirements in a year as shown in Table 2.4.2.2.

Table 2.4.2.2

Area	Airports (YR)	Aircraft Hours	Contracted Collection	In-House Collection/Year (Hours)
CONUS	120	250	200	50
Alaska Coast	*15-25	*75	75	0
Pacific Airports	*35	*125	125	**0

*** Collected every 5-10 years (based on the needs of the FAA)**

****Collection will be in-house if requirements are needed when the aircraft is deployed in the region**

NGS will collect data to support Federal leadership in the development of specifications, guidelines, and standards for conducting the development and application of new surveying instrumentation and procedures for mapping. The NGS Quality Assurance Program will collect data of small-defined areas within privately contracted work areas, by NOAA assets to assure contract accuracy compliance.

NGS will conduct fundamental research and development designed to integrate new imaging and mapping technologies into production. NGS will evaluate new surveying and remote-sensing equipment and procedures and transfer these technologies to the private sector. Studies are designed to increase efficiencies in the shoreline mapping and airport survey programs. RSD will perform accuracy assessments by comparing results obtained with a new technology to those results obtained using proven conventional high-accuracy photogrammetric techniques. The strategy is to assemble multiple datasets at a number of sites throughout the United States.

The Office of Coast Survey (OCS) is responsible for charting over 3.4 million square nautical miles of waters of our United States Exclusive Economic Zone (EEZ); near shore areas encompass approximately 350 thousand square miles of that total. Conventional methods of surveying such as multibeam, side scan sonar, and echo sounders are time intensive and, at times, a dangerous undertaking in shallow waters. However, aircraft LIDAR (Light Detection and Ranging) is a viable surveying tool that can fill the critical need to obtain timely information in these difficult and extensive areas.

OCS has obtained LIDAR data through hydrographic services contracts. The current plans are to continue obtaining this valuable form of hydrographic data in the near term through services contracts. OCS has a solicitation, NC-NJ3000-2-00009 LIDAR Hydrographic Surveying and Related Support Services Anywhere in the US, under evaluation. The current solicitation is for three years and 12 million dollars; however OCS is currently developing a *National LIDAR Survey Plan* that will define the LIDAR data collection needs beyond the next 10 years.

Through the Remote Sensing Division (RSD), OCS will develop testing plans for determining the viability of new technologies before contracts are awarded. This testing program will entail operations through all facets of the manufacturer's prescribed flight envelope to ensure advertised specifications can actually be met prior to committing taxpayer funds. It is anticipated that the aircraft operations for the instrument testing will be limited to Seattle, WA; Portsmouth, NH; and Key West, FL, to coincide with shipboard testing areas.

Flight Edit

The mission of the Flight Edit Program is to enhance the accuracy of the Federal Aviation Administration's (FAA) visual chart series through aerial evaluation, and to assist with maintaining the FAA Digital Obstruction File (DOF).

To accomplish these goals, FAA flight crews visually verify all features depicted on the Sectional and Terminal Area Charts that cover the continental United States, Hawaii, Alaska, Puerto Rico, and the U.S. Virgin Islands. Information collected on these surveys is processed by cartographers at the FAA's National Aeronautical Charting Office (NACO) and is used to improve the accuracy of future chart editions.

In addition, these visual surveys are supplemented by photographic surveys. Using an aerial camera system, flight crews from NOAA measure newly discovered obstructions, as well as known sites requested by NACO cartographers. An obstruction is classified as any object that protrudes more than 199 feet above the surrounding terrain. As such objects present a hazard to safe air navigation, their accurate charting is essential. Often, the data necessary to precisely chart these obstructions is not available by other means. In such cases, aerial photography is the sole source of cartographic information.

Information obtained visually or photographically pertaining to obstructions is used to update the DOF. This database is used for a variety of purposes. It serves as the central source of information for all obstructions to air navigation in the United States; it provides information necessary to determine minimum safe altitudes for a variety of IFR and VFR charts; it provides the data to operate the FAA's Minimum Safe Altitude Warning System (MSAWS); and it provides the data for depicting obstructions on the visual chart series.

Flight Edit photography directly supports verification of aeronautical information contained in the DOF with stereo photography. This photographic technique enables precise measurement of both the location and height of an obstruction. The accuracy of these stereographic measurements easily exceeds charting requirements.

2.4.3 Aircraft flight-hour needs

Mission	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Commerce/Transportation										
In-House	347	415	425	435	435	435	435	435	435	435
Charter	0	0	0	0	0	0	0	0	0	0
Unmet	0	0	0	0	0	0	0	0	0	0
Total	**347**	**415**	**425**	**435**	**435**	**435**	**435**	**435**	**435**	**435**

FY03 In-House Hours Support: Coastal Mapping, Airport Surveys, Contractor Oversite, RSD Sensor Research, ATCOM, and Flight Edit

2.4.4 Current in-house capability assessment

CE-550 Citation	
Max Range	1610 NM
Max Endurance	5 hrs
Operational Speeds	350 KIAS
Service Ceiling	43,000'
Useful Payload	6,848lbs
Crew Complement (Pilots-Crew)	2-4

CE-550: The Cessna Citation (CE-550) is a highly modified twin-jet engine aircraft. The Citation's primary mission is to support NGS Remote Sensing Division in its assessment of new remote sensing technologies to support nautical and aeronautical charting. NOAA's Citation has a unique side-by-side camera/sensor modification allowing two different film emulsions or sensor inputs to be exposed simultaneously. Additionally, two independent survey quality GPS antennas and precision GPS receivers provide centimeter-level horizontal accuracy with the use of a differential GPS site. The primary focus of new technology assessment in the Citation is directed toward the requirement for accurate shoreline, aeronautical obstruction, and digital elevation modeling surveys.

DHC-6: NOAA's Twin Otters conduct aerial video surveys of coastal erosion, a wide range of LIDAR missions, airborne topographical mapping, and multi-spectral scanning projects.

AC-500: NOAA operates two Rockwell Aero Commanders (AC-500S). Aero Commander N47RF has been modified to accept a high-resolution aerial camera system. In this configuration, the camera is used to verify and measure the location and heights of obstructions to air navigation. This system can also be utilized for hurricane and flood damage assessments. The aircraft can also be outfitted with a hyperspectral scanner and a variety of other remote-sensing equipment. Historically, NOS conducted aerial surveys for visual verification of aeronautical charts and high-resolution aerial photography with Aero Commander N47RF. The responsibility for this mission has recently been shifted to the Federal Aviation Administration (FAA), and it routinely requests NOAA's expertise to accomplish its mission.

2.4.5 Projected service life and replacement schedule of assets

Aircraft	Year Built	Mission Supported	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Citation II N52RF	1978	Commerce/Transportation					Remove from Service and Replace					
Citation Replacement		Commerce/Transportation				Replace N52RF						
Twin Otter N48RF	1981	Commerce/Transportation										
Twin Otter N57RF	1980	Commerce/Transportation										
Additional Twin Otter		Commerce/Transportation	Procure and Instrument									
Shrike Commander N47RF	1975	Commerce/Transportation								Replace		

Aircraft Under 20 Years
Aircraft Between 20 and 30 Years
Aircraft Between 30 and 40 Years

2.4.6 Future aircraft platform requirements

Citation Replacement

Immediate needs include a plan and budget allocation for the replacement of the aging Citation aircraft. The Citation, which supports all of NGS's requirements, is 25 years old and is getting to the end of its useful life. Unscheduled maintenance happens at a higher rate, and the availability of airframe parts is becoming limited, causing increased operating costs. Within two-three years, additional equipment will be mandated by the Federal Aviation Regulations in order to operate the aircraft in the National Airspace System.

For the Citation to accomplish its assigned missions in both the Atlantic and the Pacific, it must undergo several avionics upgrades. In order to function, the Citation must comply with new regulatory requirements to: 1) operate in a Reduced Vertical Separation Minimums (RVSM); 2) operate an Enhanced Ground Proximity Warning System (EGWPS); and 3) upgrade the radio frequency capabilities to meet the new standards.

NOAA's missions on the Citation require domestic and international flights in airspace controlled by both the FAA and the International Civil Aviation Organization, respectively. Failure to comply with the existing and future FAA regulations may restrict the Citation from operating in airspace critical to meet the needs of NOAA programs.

The platform requirements in the future must include the capability to support a wide range of remote-sensing technologies that can be flown simultaneously. The platform must have the capability of supporting at least three sensors simultaneously. The platform should support, but not be limited to, technologies such as conventional imagery and digital imagery, LIDAR, IFSAR, Hyperspectral Imaging, Global Positioning System (GPS), Inertial Motion Unit (IMU) equipment, and the testing of spaceborne imaging and sensor systems for validation.

As the mission of the Citation aircraft transitions from a platform used primarily for production work activities to a platform utilized for research and development, the need for increased system and engineering support will be required in the future. In the past, the aircraft was equipped with instrumentation that, once installed in the aircraft, stayed in the aircraft for an entire season and was never removed unless the equipment malfunctioned. System engineering and electronic technician support was basically needed only during the winter months when the aircraft was non-operational due to seasonal operational limitations (sun angle, weather, leaves on trees, etc.). This support included basic modifications to the power and instrumentation or basic reconfigurations of the camera systems.

Over the past few years, the Citation has been conducting numerous sensor evaluations requiring numerous aircraft instrumentation configuration changes throughout the year. Support will be required for installation, power modifications, installation engineering, and system testing and approval for operation. These installations will not always occur at the Aircraft Operations Center (AOC). Support from AOC engineering and systems personnel will grow as NOAA expands its investigation, testing, validation, and implementation of new remote sensing technologies in future support of programs.

Additional NOAA-operated Twin Otter

A Bell 212 helicopter was disposed of in FY02 and funds from that transaction are being applied to the purchase of an additional Twin Otter in FY03. NMAO plans to select a Twin Otter that is capable of immediately supporting marine mammal surveys and will upgrade aircraft power and modify to support remote sensing applications as time and funding is made available.

Shrike Replacement

Shrike Commander N47RF is scheduled for replacement in FY10.

2.4.7 Capability and technology enhancements required

Replacement of Citation II with more capable aircraft

The initial cost and the operating costs of the aircraft will be based on type, size, speed, range, and airport runway length needed for the mission. The aircraft should support operations of duration of four hours or more operating at altitudes as low as 4,000 feet at slow speeds of about 150 knots. The flight characteristics necessary to support remote sensing operations in the future are listed in Table 2.4.7.

Table 2.4.7 Required Flight Characteristics

Mission Type	Altitude (MSL)	Velocity (Kts)	Range (NM)	Duration (HRS)	Minimum Length of Runway for Operations (FT)	Scientific Instrumentation Payload (LBS)	Scientific Crew or System Operators
Coastal Mapping	8,000-40,000	200-350	*2300	4-6	5,000	1,200	1 or 2
Airport Surveys	12,000-15,000	200-350	1500	4-6	5,000	1,200	1 or 2
Data Quality Assurance	4,000-40,000	150-350	1500	4-6	5,000	1,200	1 or 2
Sensor Research	4,000-45,000	140-350	1500	4-8	5,000	1,200	3

***The aircraft needs a range capability to reach Hawaii (Honolulu) from California (San Francisco), with limited modifications.**

The aircraft should have the capability to reach an altitude of 40,000 feet without using a step-climb profile. The aircraft needs a range capability of reaching Hawaii (Honolulu) from California (San

Francisco), which is about 2300 nm. It also must be able to operate in the Pacific Islands, as seen in Appendix D. This can be done by purchasing an aircraft that has range duration of 2300 nm (with aircraft crew and mission instrumentations) and/or the purchase of an aircraft that can be easily modified with minimal ferry tanks. The fulfillment of this particular requirement occurs every five to 10 years or sooner for national security reasons.

Scientific Instrumentation Modifications

The aircraft should have no less than three fuselage apertures of different shapes and sizes to accept optical windows or structural plates that serve as mounting locations for a variety of remote sensing instruments.

Optical windows in the aircraft floor can be located either side by side or directly behind each other. They must have defogging and heating capability. The optical windows need to have specific characteristics so as not to limit resolution and performance of the mapping systems. One needs to have dimensions of 29.00 x 22.75 inches, to accommodate large format cameras;
one in the fuselage needs to be easily removable for use with instrumentation because the sensor will be affected by optical properties. A pressurized vessel in which the sensor hangs inside the vessel may be employed.

Fuselage apertures might call for possible modifications in the nose or tail section of the aircraft. Downward-looking sensors should have the ability to be tilted from nadir to 25 degrees forward or aft to support operations.

Every sensor on board should have an aided inertial position and orientation system designed specifically for direct georeferencing of airborne sensor data. The system should have integrated precision GPS (L1/L2 antennas) with inertial technology to provide real-time and post-processed measurements of the position, roll, pitch, and heading of airborne sensors. The position of the FAA-approved antennas (Figure 3) on the fuselage should be as close as possible to the sensor locations. The installation of an upward looking mounting plate to support a radiometric sensor should be installed for atmospheric modeling.

The platform should have interchangeable instrumentation pods on the wings that can carry active and passive remote sensors and in-situ sensors. It should also possibly have wingtip pylons that can carry canister-mounted sensors and structures on the top and the bottom of the fuselage to provide additional capacity for other sensors. In addition, to the suite of sensors that will support remote sensing work, the aircraft should be equipped with a dropsonde tube to support future weather research projects. The aircraft also should be outfitted with gas or aerosol inlets or other sensors that can support future NOAA atmospheric projects.

The various types of instruments that may be carried in support of these missions require electrical power supplied by the aircraft. The aircraft scientific power system should provide at least 400 amperes of

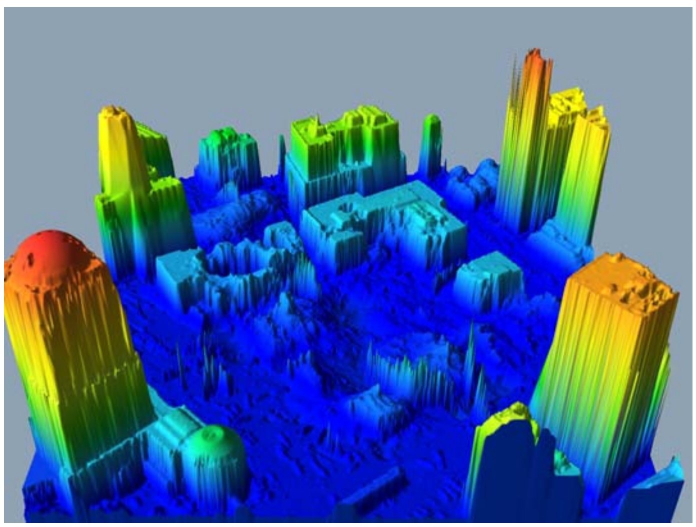
28VDC power for scientific systems. Of that power, inverters should be able to provide up to 50 amperes of 115VAC. Both DC and AC power should be available at drops in at least four locations in the cabin, close to where scientific equipment is anticipated to be installed. Control switches and monitoring gauges for this system should be installed in the cockpit.

An on-board Auxiliary Power Unit (APU) would allow for running instrumentation while on the ground to support conducting tests and calibration, as well as providing power for scientific systems during engine start. An APU should be considered as part of the design, unless the added weight significantly decreases scientific payload or aircraft range. Also, additional supplemental cooling of the cabin and cockpit is required so crew and instrumentation can effectively operate in warmer climate areas.

2.4.8 New ways of doing business

NGS will continue to fulfill its mission and, to the greatest extent possible, rely on outsourcing for routine data collection, management, and processing, as well as for contractible administrative and support functions. This includes the collection of remote-sensing data to support routine NGS data products. To make this evolution happen over the next few years, a large portion of NGS's annual budget for data collection and processing of data will go to private organizations. In addition, NOAA will work to build private-sector capability through technology transfer.

2.5 Homeland Security



NOAA's core missions of environmental prediction and management are manifested in more than 80 capabilities that support America's efforts to prepare for and, if necessary, respond to terrorist attacks. Best known are NOAA's hazardous materials spill response, atmospheric and waterborne dispersion forecasting, vessel monitoring systems, and support for communities and first responders, including training, decision-making tools, rapid on-site weather forecasts to support emergency operations, and civil emergency alert relay through NOAA Weather Radio. But NOAA is also ready to quickly provide its other assets–ships, aircraft, global observation systems, and professional law enforcement officers--to serve the Nation when the need arises.

2.5.1 Airborne data collection requirements

Through its core capabilities and strategic investment, NOAA will expand its support for homeland security, coordinating delivery of its products, services, and capabilities to Federal, state, and local emergency managers and responders, and strengthening its own infrastructure to protect agency personnel, facilities, and information services.

Requirements for homeland security currently include physical security of facilities, data input to models that predict coverage and dispersion rates for release of hazardous materials into the atmosphere or water, and fast response with different remote sensing capabilities wherever needed. NOAA Corps officers and NOAA aircraft could be used in the following capacity to assist in homeland security.

NOAA Corps:

The Commissioned Officer Corps of NOAA is the smallest of the Nation's seven uniformed services. NOAA Corps officers predominantly have science and engineering backgrounds. Officers serve in operational billets aboard survey and research ships and aircraft, lead mobile field parties, and conduct state-of-the-art diving operations and training. Ashore, officers serve throughout NOAA's extensive science and management establishment. NOAA Corps officers could serve in the following capacities:

- NOAA Corps officers can provide liaison capability between DHS, DOD, and other Federal agencies in areas of classified information exchange. NOAA Corps officers have historically worked with the Defense Intelligence Agencies and CIA on the use of classified information to further NOAA's research and remote sensing capabilities.

- NOAA Corps officers have routinely served as liaisons to DOD and the USCG. The existing rank structure and status as a commissioned officer allows for smooth transition between departments and agencies. NOAA Corps officers frequently train with other DOD services and agencies, and are familiar with the basic workings of these agencies. Therefore, transitions would be smoother during emergency situations.

- The mechanism already exists (U.S.C. Title 33, Section 855) to allow for the rapid transfer of NOAA Corps officers, ships, and aircraft from the Department of Commerce to DOD. Existing NOAA Corps Regulations (Chapter 5, Section 05102) provide that officers of the NOAA Corps "may serve with DOD during peacetime or during a national emergency."

- As an example, in the **GULF WAR**, in addition to commanding the NOAA Ship MT MITCHELL on its cruise to the Arabian Gulf in 1992, NOAA Corps officers served as liaisons to the USCG and the American Embassies in the Gulf region immediately after the end of hostilities (Feb. –- Oct. 1991), specifically Saudi Arabia, Kuwait, and Bahrain. These liaisons coordinated the HAZMAT response and airborne research on oil spill and oil well fires, providing briefings to senior military and ambassadors.

NOAA aircraft:

NOAA's airplanes and helicopters are flown in support of the agency's mission to promote global environmental assessment, prediction and stewardship of the Earth's environment. Based out of MacDill Air Force Base in Tampa, FL, NOAA's aircraft operate throughout the United States and around the world; over open oceans, mountains, coastal wetlands, and Arctic pack ice. These versatile aircraft provide scientists with airborne platforms necessary to collect the environmental and geographic data essential to their research. Possible missions include:

- Provide additional hurricane research and reconnaissance support if USAF assets are reassigned. If USAF Reservists are activated for homeland defense, NOAA "hurricane hunter" aircraft could be made the primary response platforms for hurricane reconnaissance. NOTE: NOAA only has two aircraft to support this effort, compared to the eight-10 currently used by the USAF Reserve.

- Support airborne mapping/remote sensing efforts. Efforts similar to those conducted by the Cessna Citation at the World Trade Center and Pentagon could be used at other sites, with other technologies available as needed. Other NOAA aircraft can provide remote sensing for air chemistry efforts such as tracking toxic gases.

- Provide long-, medium, and short-range maritime patrol as tasked by DHS.

- Support logistics efforts (including secure executive transport) with both fixed-wing and rotor aircraft. In an emergency, NOAA's aircraft could be used to provide transport for senior government officials to/from restricted areas. NOAA aircraft and NOAA Corps pilots routinely work with FAA on accessing airspace for unique scientific and research missions. This experience could be used to support unique or emergency needs of DHS.

- Provide flight security assessments – as are currently being conducted by Bell 212 and MD 500 helicopters at MacDill AFB.

- Provide sophisticated airborne chemical detection support. Similar to the remote sensing effort previously mentioned, NOAA aircraft and pilots have a lot of experience in flying various equipment designed for detecting trace gases in a constantly changing atmospheric environment.

2.5.2 NOAA programs and initiatives requiring aircraft support

Homeland Security is an evolving area for NOAA and the future requirements have not yet been determined.

2.5.3 Aircraft flight hour needs

Mission	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Homeland Security										
In-House	105	155	105	155	105	155	105	155	105	155
Charter	0	0	0	0	0	0	0	0	0	0
Unmet	0	0	0	0	0	0	0	0	0	0
Total	**105**	**155**	**105**	**155**	**105**	**155**	**105**	**155**	**105**	**155**

FY03 In-House Hours Support: MacDill AFB Security, and RSD National Response

2.5.4 Current in-house capability assessment

CE-550: The Cessna Citation has supported numerous projects in response to national needs. These projects have included imagery of floods from hurricanes and spring thaw of snow in the Midwest, environmental photography in support of harmful algal blooms, photography of damaged coral reefs from grounded ships, photography of pfisteria in the Chesapeake Bay, and use of LIDAR to map the World Trade Center (WTC) and the Pentagon after September 11, 2001.

The usefulness and value of the WTC and Pentagon datasets has highlighted the capabilities of the National Geodetic Survey and NOAA Citation II. These capabilities to meet baseline mapping needs and the continuing threat of future attacks has thrust NGS in the middle of Homeland Security efforts. For example, over the past year the aircraft has been utilized to provide 12 major city mapping data sets to the Army Joint Precision Strike Demonstration Program Office and the National Imagery and Mapping Agency (NIMA). This relationship with the U.S. Army and NIMA allows NGS access to their LIDAR systems and meets the need for a
CONUS response capability within six hours of an event. This capability did not exist before September 11, 2001.

Bell 212: The Bell 212 helicopter has been used for a variety of missions, including MacDill AFB security checks, nautical charting via laser hydrography, and base camp relocations, as well as for establishing geodetic bench-marks in remote locations, surveying coastlines, assessing oil spill damage, conducting low-level survey work, and providing logistical support for environmental studies.

MD-500: The MD500 is transportable on a cargo airplane for relocation to distant worksites and international operations. NOAA's MD500 helicopter has been used to assess oil spill damage, survey coastal erosion, and conduct MacDill AFB security checks, and is capable of operating off ships.

2.5.5 Projected service life and replacement schedule of NOAA assets

Aircraft	Year Built	Mission Supported	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Citation II N52RF	1978	Homeland Security					Remove from Service and Replace					
Citation Replacement		Homeland Security				Replace N52RF						
Bell 212 N61RF	1979	Homeland Security			Remove from Service and Replace							
MD-369 (500) N59RF	1979	Homeland Security			Remove from Service and Replace							
Bell 212 & MD 369 Replacement		Homeland Security			Replace N61RF & N59RF							
Small Environmental Research Aircraft		Homeland Security	Procure and Instrument									

Aircraft Under 20 Years
Aircraft Between 20 and 30 Years
Aircraft Between 30 and 40 Years

2.5.6 Future aircraft platform requirements

Citation Replacement

A FY06 initiative will be submitted to replace the aging Cessna Citation with an upgraded medium-sized jet aircraft capable of conducting all of the current and future required missions that the current aircraft is capable of performing.

New Twin-engine Helicopter

A FY05 initiative has been submitted to replace both helicopters (Bell 212 and MD 500) with a light twin- turbine helicopter.

Small Environmental Research Aircraft (SERA)

NOAA Research is proposing to replace the capabilities lost in the Long-EZ aircraft accident in FY02 with a single-engine, light airplane instrumented to measure turbulence in-situ and surface state parameters remotely to support climate studies, air chemistry research, and homeland security.

2.5.7 Capability and technology enhancements required

No capability enhancements have yet been identified for this new NOAA mission.

2.5.8 New ways of doing business

UAVs and RPVs could be used to monitor sensitive areas within the United States to immediately alert officials to the release of hazardous materials.

2.6 Integrated Global Observation and Data Management System

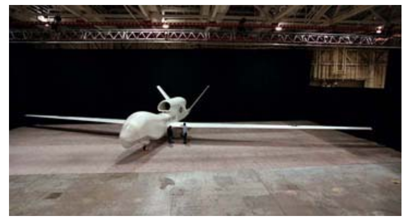
NOAA will work with its local, regional, national, and international partners to develop global-to-local environmental observations and data management for comprehensive, continuous monitoring of coupled ocean/atmosphere/land systems. This network will enhance NOAA's ability to protect lives and property, expand economic opportunities, understand climate variability, and promote healthy ecosystems. As part of building this capability, NOAA has begun to inventory its observing and data-management capabilities. It has designed an architectural process for evaluating the efficiency of its data observation and management system and increasing the multiple use of observation platforms and availability of real-time data. By the end of FY03, NOAA will develop an agency-wide Strategic Plan. The plan will respond to NOAA's multiple-user requirements that integrate atmospheric, oceanic, terrestrial, and freshwater observations and data management to enhance achieving all NOAA's mission goals.

2.6.1 Airborne data collection requirements

Data requirements for a global observing network are immense. NOAA proposes to use a variety of inter-related sensors throughout the world to monitor and assess the health of the environment.

2.6.2 NOAA programs and initiatives requiring aircraft support

Profiling the Global Ocean and Atmosphere



NOAA atmospheric research scientists are exploring the concept of a new long-term global observing system to provide detailed profiles of the Earth's atmosphere and oceans. In addition to using satellites and ocean buoys to acquire data to support profiling, this system would use unmanned aerial vehicles (UAV's) in the lower stratosphere to launch dropwindsondes over a number of equally spaced, fixed locations over oceans and polar regions. The UAV's would also descend to the Earth's surface to provide details of clouds, aerosols and chemistry. The objective of the effort would be to improve weather and climate prediction by addressing the important long-term climate issues. Acquisition of data around the clock would provide better trend analysis of global change by addressing unresolved climate change questions and by providing data that could be used to improve long-term climate models. UAV's have a greater range, altitude and duration than most manned aircraft.

The atmospheric research community is interested in initiating a proof of concept mission in FY05 to begin a three-five year mission. Assuming that the concept of using Global Hawks to improve long-term climate forecasts is proved, the research community would subsequently initiate an effort to operate a total fleet of UAV's deployed from bases worldwide. The proposed system would improve short- and medium-range weather forecasts, as well as support the primary mission of global profiling to predict long-term (decadal to centennial time scales) climate change.

In addition to dropwindsondes that acquire pressure, temperature, humidity and wind data, other in-situ instruments would collect ozone, water vapor, carbon monoxide, carbon dioxide, condensation nuclei, and ice particle information. For an intensive flight series, the aircraft would be modified with instruments that measure nitrogen oxides, sulfur oxides, organic nitrates, hydrogen peroxide, hydroxyl radicals, halogen oxides, peroxy radicals, hydrocarbons, formaldehyde, long-lived halogen species, nitrous oxide, methane, sulfur hexafluoride, soot particles, ice nuclei, liquid cloud droplets, cloud water, and aerosol chemical composition.

Over time, these aircraft may also be found to be well suited for high-altitude in-situ data sampling in the hurricane environment.

The incorporation of UAV's into NOAA research protocol would resolve some limitations that exist in climate and weather forecast models, as well as provide crucial satellite calibration data and coastal oceanography information

The knowledge and insights gained with the acquired data set will address climate processes acting in the upper troposphere/lower stratosphere. Specific scientific issues to be addressed include particle production at the tropical tropopause, mixing between and within the upper troposphere and lower stratosphere, and scales of variability in the UT/LS. This unique data set should allow us to explore the existence of a circulation in the lower stratosphere that is the "mirror image" of the Walker circulation in the underlying troposphere. Additionally, gravity wave characterizations and transport modeling studies using the data collected will provide opportunities for increasing our understanding of transport processes in these under-sampled regions of the atmosphere.

The Global Hawk is a UAV developed for the U.S. Air Force by Ryan Aeronautical Center of the Northrop Grumman Corporation. Global Hawk, which first flew in February 1998, is a jet-powered aircraft with a conventional aluminum fuselage and graphite composite wings and appendages. The maximum estimated range of the aircraft is one-half of the Earth's circumference (11000 nm). The maximum operating altitude is 65,000 feet. The current payload capacity exceeds 1000 pounds. Global Hawk flies an integrated synthetic aperture radar and electro-optic/infrared reconnaissance payload for the U.S. Air Force. The Global Hawk has been designed to fit seamlessly into the national airspace system. It has a standard mode 3/A and mode C transponder, and a satellite communication relay that allows the command and control operator (CCO) to talk to ATC over VHF and UHF radio even though the CCO is hundreds of miles away in the command and control shelter. It is currently operated out of Edwards Air Force Base (co-located with NASA Dryden Flight Research Center) for the U.S. Air Force, by Ryan Aeronautical, under a FAA-issued certificate of authorization.

More details about the Global Hawk UAV are available at
http://www.northgrum.com/Corp_web/news/rev_mag/review09_18.html

2.6.3 Aircraft flight hour needs

NOAA (Un-Manned) Flight Hour Requirements FY03 – FY12

Mission	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Pacific Plus Global Hawk (UAV)										
In-House				240	480	6000	6000	6000		
Charter										

2.6.4 Current in-house capability assessment

NOAA currently does not own Unmanned Aerial Vehicles.

2.6.5 Projected service life and replacement schedule of assets

Not Applicable.

2.6.6 Future aircraft platform requirements

Aircraft	Year Built	Mission Supported	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Global Hawk (UAV)		Global Observation			Procure and Instrument							

Aircraft Under 20 Years
Aircraft Between 20 and 30 Years
Aircraft Between 30 and 40 Years

2.6.7 Capability and technology enhancements required

Procurement and instrumentation of unmanned aerial vehicles to incorporate into the global network system is paramount to NOAA's ability to monitor the entire earth.

2.6.8 New ways of doing business

NOAA anticipates utilizing new technology, including Unmanned Aerial Vehicles, to integrate into the global network.

3.0 Cost, Schedule, and Performance

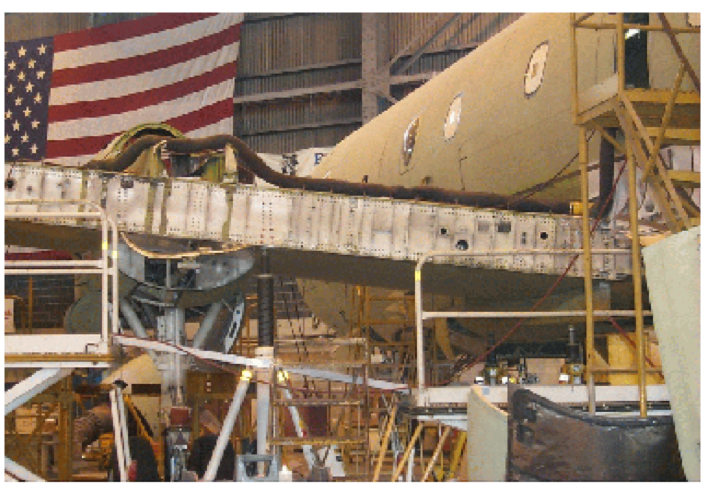
Cost: The incremental funding needed to meet changing aircraft platform and instrumentation requirements of NOAA's programs over the next 10 years is $140.5 Million in PAC funds, and a $8.1 Million increase in ORF funds over the FY04 President's Budget. These estimates are based on FY03 dollars. Table 3.0 summarizes the ORF and PAC projections for the next 10 years.

Table 3.0 Funding required to Accomplish Aircraft 10-Year Plan ($ in millions)*

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ORF (Aircraft Services)	16.2	18.3	20.2	23.3	22.0	23.1	23.5	27.0	27.1	26.4
PAC (Aircraft Replacement)	8.4	9.1	17.6	101.9	1.9		1.9	7.9	8.1	1.2
Total	24.6	27.4	37.8	125.2	23.9	23.1	25.4	34.9	35.2	27.6

* Does not include UAV cost estimate

Schedule: During the next decade, six active NOAA aircraft are recommended for removal from service: Turbo Commander N53RF, Lake Amphibians N64RF and N65RF, Bell 212 Helicopter N61RF, MD500 Helicopter N59RF, and Cessna Citation N52RF. Five of the existing aircraft are recommended for replacement: Turbo Commander, Citation, two Shrikes, and Helicopters (Bell 212 and MD500 for one replacement helicopter). Ten additional aircraft are required to meet increasing needs of the NOAA line offices; these include a very light aircraft for turbulence and flux measurements, an additional Twin Otter, an additional P-3, an additional high-altitude jet, and five Global Hawk UAVs. Table 3.1 shows the age of the current fleet and the missions supported by each aircraft. Table 3.2 shows the projected service life and recommended replacement schedule for NOAA aircraft. By FY12, NOAA should have a fleet of 14 manned aircraft and five Global Hawk UAVs.



3.1 Fleet Replacement Details

Table 3.1 Age of the Fleet and Missions Supported

Aircraft	Year Built	Mission(s) Supported	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
WP-3D N42RF	1975	WWI, CV										
WP-3D N43RF	1976	WWI, CV										
Additional P-3		WWI, CV	Acquire		SDLM and Instrument							
G-IVSP N49RF	1994	WWI, CV										
Additional High Altitude Jet		WWI, CV				Procure and Instrument						
Citation II N52RF	1978	CE, CT, HS					Remove from Service and Replace					
Citation Replacement		CE, CT, HS				Replace N52RF						
Twin Otter N48RF	1981	CE, CT, CV										
Twin Otter N57RF	1980	CE, CT										
Additional Twin Otter		CE, CT	Procure and Instrument									
Turbo Commander N53RF	1974	WWI		Remove From Service and Replace								
Turbo CDR Replacement		WWI		Replace N53RF								
Shrike Commander N47RF	1975	CE, CT								Replace		
Shrike Commander N51RF	1977	WWI									Replace	
Bell 212 N61RF	1979	CE, HS			Remove from Service and Replace							
MD-369 (500) N59RF	1979	CE, HS			Remove from Service and Replace							
Bell 212/MD 369 Replacement		CE, HS			Replace N61RF & N59RF							
Lake LA-27 N64RF	1991	CE		Remove From Service								
Lake LA-27 N65RF	1991	CE	Remove from Service									
Small Environmental Research Aircraft		CE, CV, HS	Procure and Instrument									
5 Global Hawk (UAV)		GO, CV			Procure and Instrument							

WWI = Weather/Water Impacts
CE = Coastal/Ecosystem
CT = Commerce/Transportation
CV = Climate Variability
HS = Homeland Security
GO = Global Observation

Aircraft Under 20 Years
Aircraft Between 20 and 30 Years
Aircraft Between 30 and 40 Years

Projected Service Life and Recommended Replacement Schedule for NOAA Aircraft

(as of January 22, 2003)

Current/Replacement Aircraft	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
WP-3D N42RF 8914 Hours	SDLM				SDLM				SDLM	
WP-3D N43RF 7839 Hours				SDLM				SDLM		
Additional P-3 $6.5 M PAC + 1.9M ORF	Acquire Aircraft		SDLM				SDLM			
G-IVSP N49RF 1876 Hours		Engine Midlife								
Additional High Altitude Jet ($90 M)		Submit FY06 Initiative		Procure	Instrument					
Citation II N52RF 7316 Hours					Dispose					
Citation Replacement ($20 M)		Submit FY06 Initiative		Procure and Instrument						
Twin Otter N48RF 13325 Hours									Re-Wing	
Twin Otter N57RF 15775 Hours								Re-Wing		
Additional Twin Otter ($1.4 M)	Procure									Re-Wing
Turbo Commander N53RF 11827 Hours	Dispose est $400K	Apply Funds towards Replacement Lease to Own Aircraft								
Turbo Commander Replacement $1.55M	Initiate Lease to Own	Complete Procurement with FY04 Funds								
Shrike Commander N47RF 12462 Hours								Replace		
Shrike Commander N51RF 8553 Hours									Replace	
Bell 212 N61RF 9089 Hours			Dispose est $900K	Apply Funds towards Light Twin Helo						
MD-369 (500) N59RF 3202 Hours			Dispose est $350K	Apply Funds towards Light Twin Helo						
Light Twin Engine Helicopter ($6M)	Submit FY05 Initiative		Procure and Instrument							
Lake LA-27 N64RF 1464 Hours		Dispose est $100 K	Apply Funds towards Light Twin Helo							
Lake LA-27 N65RF 1195 Hours	Dispose est $100K	Apply Funds towards Replacement Lease to Own Aircraft								
LO Funding Required										
Small Environmental Research Aircraft	Procure and	Instrument								
5 Global Hawk (UAV)	Submit FY05 Initiative		Procure and	Instrument						

Blue	Aircraft Required by NOAA through FY12.
Red	Aircraft Sold by FY12.
Green	Aircraft Acquisitions Required to Maintain NOAA Capabilities through FY12.
Grey	Aircraft Acquisitions Required to Increase NOAA Capabilities through FY12.

3.2 Service Life Extension Program for WP-3D Aircraft

In September 2001, NOAA completed an *Assessment of the Condition of the National Oceanic and Atmospheric Administration WP-3D "Hurricane Hunter" Aircraft*. In summary, NOAA's two WP-3Ds have relatively little corrosion when compared to P-3 aircraft currently being operated by the U.S. Navy. The NOAA WP-3D aircraft were manufactured in 1975 and 1976 and have very low total flight hours with fewer landing cycles than Navy aircraft of comparable age. Additionally, the NOAA aircraft are hangared and are therefore less susceptible to the environmental effects that hasten aircraft corrosion.

The Naval Aviation Depot (NADEP JAX), located in Jacksonville, Florida, is responsible for all Navy P-3 maintenance. The Commanding Officer, NADEP, has stated that the NOAA WP-3D aircraft "are in considerably better material condition than the Navy's P-3 fleet," and "the continued maintenance plan ... will conceivably extend the a/c [aircraft] structural life out to year 2020." (See attached Department of the Navy memorandum 16 August 2001, *Standard Depot Level Maintenance (SDLM) on NOAA Aircraft* (Figure 3.2.1).

NOAA WP-3D aircraft have been maintained on a required 48-month interval maintenance plan, the Standard Depot Level Maintenance (SDLM) program at NADEP JAX, during which the aircraft are completely stripped of paint and inspected for corrosion. Any defects, including corrosion, discovered in these areas during this inspection are repaired and treated, and in some cases structural components are removed and replaced. The program has been maintained by NOAA to ensure critical components of the aircraft will not fail during the extreme rigor of severe weather flight.

The benefits of maintaining a comprehensive maintenance program are increased aircraft safety in hostile weather environments and the detection of potential material deterioration conditions which, if undetected, would lead to increased long-term maintenance costs. NOAA expects to exceed the design service life of its WP-3D aircraft by continuing the regularly scheduled SDLM program. The cost of replacing the aircraft with new WP-3Ds, if available, would be well in excess of $100 million dollars each, plus the extensive cost of modification and instrumentation necessary for research.

The changing operational flight tempo and reduced flight hours for NOAA's WP-3D aircraft during the last decade warrants a revised maintenance schedule for the aircraft. The aircraft are now only flying 1000 hours between SDLM inspections (less than 300 hours per year) and have been hangared between deployments since 1992. No major problems have been found during the last three SDLM inspections on NOAA aircraft except for wing spar replacements on both aircraft. Barring any major discrepancies found during the SDLM this year on N42RF, AOC will propose extending the SDLM cycle out an additional 12 months to reflect the changing mission tempo of the aircraft. The NADEP engineering maintenance staff concurs with this approach. Extending the SDLM for both aircraft will reduce recurrent SDLM costs by 20 percent over the life of the aircraft and permit additional program scheduling of the aircraft. AOC is also studying the requirements to change the required Phase inspection program from 300 hours to 400 hours to enhance mission scheduling flexibility. These proposed changes will be studied and endorsed by both NADEP and Lockheed Martin prior to implementation.

AOC will also incorporate additional structural inspections on fatigue critical components discovered during the Service Life Assessment Program (SLAP) being undertaken by the Navy. NOAA aircraft do not meet the inspection criteria established for Navy aircraft by the SLAP (18,000 flight hours and 21,000 landings). However, AOC will proceed with the inspections to cover potential areas of failure caused by flights into extremely turbulent weather.

AOC has also initiated an MOU with NAVAIR to perform a Fatigue Life Expended (FLE) Analysis on NOAA WP-3D aircraft to determine the available life remaining in the platforms. NOAA requires an analytical tool to weigh service usage with respect to a fatigue test standard. FLE life has been tracked by the Navy for its P-3 fleet and will be tracked relative to a test- demonstrated fatigue life. The results of the analysis will provide NOAA leadership with the essential information required to make decisions concerning the future of these platforms. Once the study is complete, a quantitative value of useful aircraft life remaining will be assigned to both aircraft. This tool will provide NOAA with the means to plan for future replacement, a service life extension program, or continued maintenance and component overhaul of the aircraft.

Figure 3.2.1

DEPARTMENT OF THE NAVY
NAVAL AVIATION DEPOT
NAVAL AIR STATION
JACKSONVILLE, FLORIDA 32212-0016

IN REPLY REFER TO
6.2.2/13000
16 Aug 2001

From: Commanding Officer, Naval Air Depot, Jacksonville
To: Captain R. W. Maxson, Director, NOAA Aircraft Operations Center

SUBJ: STANDARD DEPOT LEVEL MAINTENANCE (SDLM) ON NOAA AIRCRAFT

1. Naval Air Depot (NADEP), Jacksonville has been performing SDLM work on NOAA aircraft for several years. This maintenance plan, consisting of a SDLM work phase every four years, seems to be an optimum time frame for your aircraft. The work performed by NADEP returns your aircraft to an excellent material condition ready to serve another four years as a national asset. Overall, the aircraft, with their low flight hours, are in considerably better material condition than the Navy's P-3 fleet. We are not seeing the corrosion problems or amount of corrosion that the Navy is experiencing on their aircraft. In addition to the fixed 4-year cycle of SDLM, the maintenance performed by the NOAA AOC personnel in between SDLMs serves to maintain the aircraft in tiptop condition and reduce material degradation.

2. The major advantage to the SDLM level of rework is the increased number of areas/ zones that are inspected, and NDI requirements at each rework interval, vice the inspection criteria under the PDM concept. Thus, SDLM greatly reduces the likelihood of a material deterioration condition going undetected over a longer period of time. Based on the current material condition of your aircraft, relatively low flight hours, and the continued maintenance plan, both at NADEP and at your AOC, this program will conceivably extend the a/c structural life out to year 2020. This estimate takes into consideration the extremely hostile environment that your aircraft routinely operates in.

3. POCs are Mr. Jack Gross, P-3 Planner & Estimator for In-Service Repair work, at (904) 542-5602 and Mr. Dave Johnson, P-3 PDM/SDLM Program Manager for SDLM, at (904) 542-5282. DSN prefix is 942.

Michael R. Delp
MICHAEL R. DELP
By direction

3.3 Instrumentation Upgrades

A detailed discussion of the recommended instrumentation upgrades to the current NOAA fleet of aircraft is contained in Chapter 5 of this report. Additionally, Appendix B details the G-IV-specific instrumentation upgrades. Table 3.3.1 outlines the status of aircraft and instrumentation upgrades that were requested in the FY04 budget initiative process.

Table 3.3.1 Aircraft and Instrumentation Initiatives submitted by NMAO in FY04

FY04 Aircraft and Instrumentation Initiatives					
Aircraft	**Initiative**	**FY**	**Cost**	**Total**	**PAC/ORF**
G-IV	Instrumentation Upgrades	2004	4.600	**4.6**	**2004 PAC**
Turbo Commander	Turbo Commander Replacement	2004	1.750	**1.550**	**2004 PAC**
WP-3D	Inertial Nav Upgrades	2004	1.645	**1.645**	**2004 PAC**
Required Regulatory ORF	Required Regulatory Upgrades	2004 ORF	0.307	**1.650**	**2004 PAC & ORF**
Required Regulatory PAC	Citation II Avionics Upgrades (PAC)	2004 PAC	1.343		
	Twin Otter Autopilot Upgrade (PAC)				
	Terrain Awareness and Warning System (PAC)				
	Head-up Display (HUD) for the NOAA G-IV (PAC)				
	Upgrade G-IV Avionics Suite (PAC)				
All	Scientific Instrument Maintenance	2004	0.500	**1.465**	**2004 ORF**
G-IV	Mid-Life Maintenance	2004	0.500		
All	Aircraft Maintenance	2004	0.465		

Table 3.3.2 outlines the status of aircraft and instrumentation upgrades that were requested in the FY05 budget initiative process.

Table 3.3.2 Aircraft and Instrumentation Initiatives submitted by NMAO in FY05

<table>
<tr><th colspan="6">FY05 Aircraft and Instrumentation Initiatives</th></tr>
<tr><th>Aircraft</th><th>Initiative</th><th>FY</th><th>Cost</th><th>Total</th><th>PAC/ORF</th></tr>
<tr><td>WP-3D</td><td>Cloud Physics Upgrade</td><td>2005</td><td>0.660</td><td rowspan="5">2.037</td><td rowspan="5">2005 PAC</td></tr>
<tr><td>WP-3D</td><td>Radiometric Temp & Fast-Response Humidity</td><td>2005</td><td>0.230</td></tr>
<tr><td>WP-3D</td><td>Liquid and Total Water Upgrade</td><td></td><td>0.100</td></tr>
<tr><td>WP-3D</td><td>Data Acquisition Display</td><td>2005</td><td>0.297</td></tr>
<tr><td>WP-3D</td><td>AVAPS Improvement</td><td>2005</td><td>0.750</td></tr>
<tr><td>Twin Otter N48</td><td>Air Chemistry Upgrades</td><td>2005</td><td>0.400</td><td>0.400</td><td>2005 PAC</td></tr>
<tr><td>Shrike, Turbo Commander</td><td>TAWS</td><td>2005</td><td>0.200</td><td rowspan="3">0.575</td><td rowspan="3">2005 PAC</td></tr>
<tr><td>Shrike N47</td><td>Mission Upgrades</td><td></td><td>0.125</td></tr>
<tr><td>Citation</td><td>RVSM, EGPWS</td><td>2005</td><td>0.250</td></tr>
<tr><td>WP-3D</td><td>Nav Upgrade</td><td>2005</td><td>0.845</td><td>0.845</td><td>2005 PAC</td></tr>
<tr><td>Twin Otter</td><td>Twin Otter Standardization</td><td>2005</td><td>1.200</td><td>1.200</td><td>2005 PAC</td></tr>
<tr><td>Helicopter</td><td>Light Twin Helicopter</td><td>2005</td><td>9.000</td><td>9.000</td><td>2005 PAC</td></tr>
<tr><td>WP-3D</td><td>Additional WP-3D</td><td>2005</td><td>6.500</td><td>6.500</td><td>2005 PAC</td></tr>
<tr><td>WP-3D</td><td>Additional WP-3D O&M</td><td>2005</td><td>1.900</td><td>1.900</td><td>2005 ORF</td></tr>
</table>

3.4 Cost Competitiveness of NOAA Platforms and Data Collection Systems

For the past three years (FY00 – FY03), the Aircraft Operations Center has not raised its in-house (NOAA) light aircraft user fees, which were cited in *NOAA Light Aircraft Operations: An Independent Internal Assessment, February 2000 Study* by Mitretek Systems, Inc., as being 32 percent less expensive than fees charged for commercial aircraft use. Additionally, many of the aircraft are significantly modified and instrumented for the mission(s) they perform, making contracting in some cases difficult. The NOAA line offices can choose whatever aircraft they want to support their missions; therefore, the Aircraft Operations Center aircraft must remain competitive.

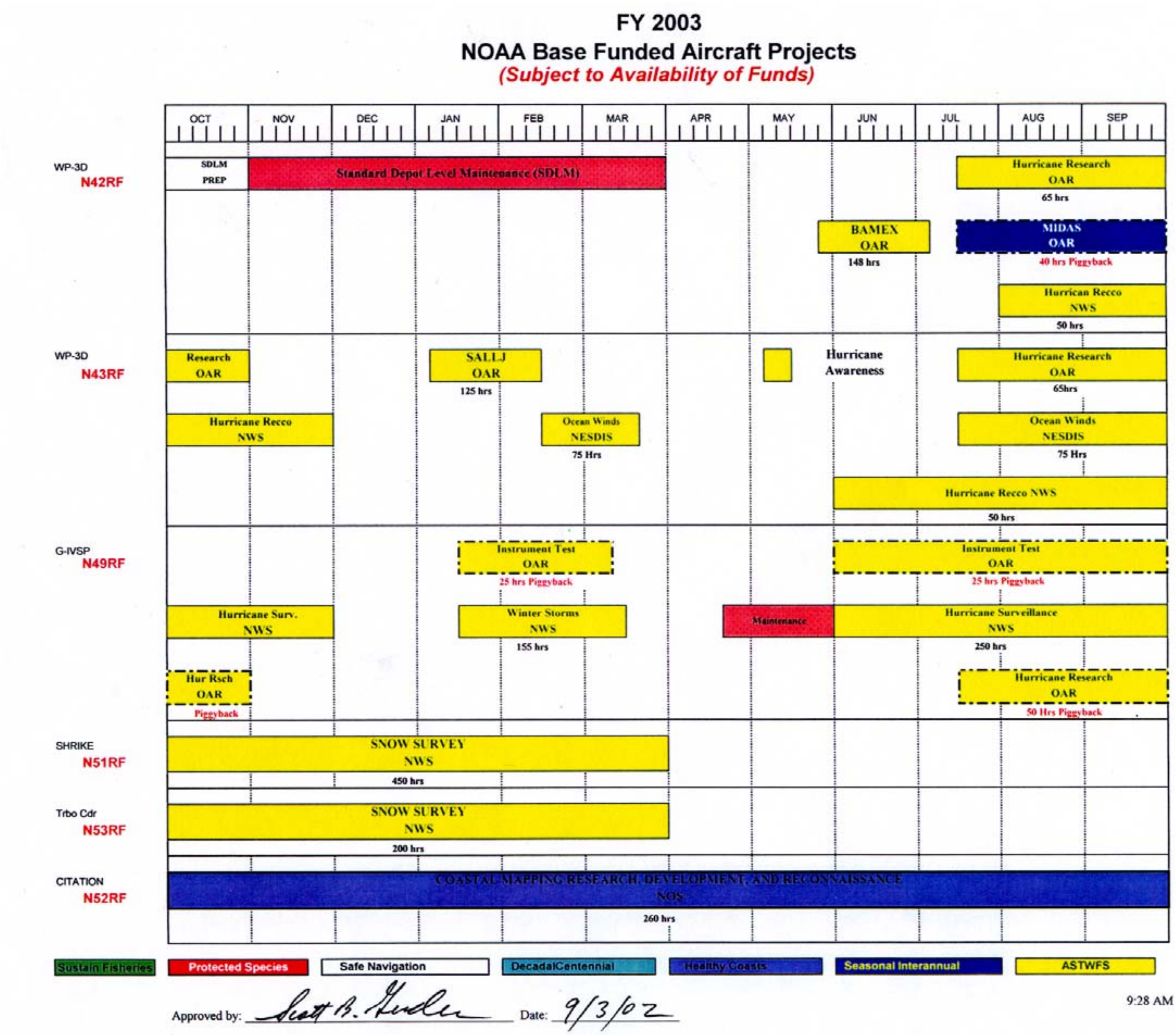
The meteorological and atmospheric physics community recognizes the need to use the NOAA heavy aircraft as cost effectively as possible. During the Heavy Aircraft Workshop in July 2000, they determined that a more cost-effective use of the aircraft could be achieved through increased cooperation among the various aircraft users, such as the air chemistry users and the meteorological and atmospheric physics research and operational users. There are many examples of this type of cooperation that could be cited. The WP-3D users in OAR should cooperate to fully utilize the aircraft. This could be done in some cases by combining missions or piggybacking some instruments onto other experiments. To do this, investigators who plan to use the aircraft should compare their requirements and indicate their constraints well in advance to
allow ample time for accommodation. This would require an indication of the aim, theater of operation, and instrument load planned for the host investigation to determine the feasibility of collaboration and possible payoffs. Such cooperation has been informally discussed by the air chemistry and hurricane research and operations programs.

A more versatile use of the WP-3Ds could also be achieved by developing a means to swap the belly Doppler radars with other NOAA sensors -- for example, the Polarimetric Scanning Radiometer (PSR) series of imaging microwave radiometers. Currently, there is no simple way to download the radar and upload the PSR equipment. However, the capability to reconfigure the WP-3D bomb bay with a versatile fairing suitable for housing a wide range of remote-sensing equipment has been demonstrated on the NASA WFF WP-3D and a Navy P-3. A similar fairing and swap-out scheme could be developed for at least one of the NOAA WP-3Ds.

While the G-IV currently is used principally for operational support, many of these missions are flown with a lightly instrumented aircraft with only dropsonde capability. Other researchers could add instruments to conduct experiments on the aircraft when it is being used for the operational missions. These piggyback missions could provide potentially important information for use in operations.

On the FY03 aircraft allocation plan, piggyback projects on the WP-3Ds and G-IV totaling 140 hours are shown with the associated projects (Table 3.4)

Table 3.4 Piggyback Projects on NOAA Base-Funded Aircraft



4.0 Human Resources and Facilities Requirements

Human Resources Requirements

Historically, AOC has had an excellent retention and recruitment rate. On average, only one government service employee has decided to leave for other than retirement reasons per year. If allowed to recruit, replacement of government service employees has occurred in relatively short time frames, with the exception of a few specialty fields. Recruitment of NOAA Corps aviators occurs through the NOAA Corps assignment process. In addition, the NOAA Corps recruits individuals with specialized skills (WP-3D navigators and pilots, helicopter pilots) from other uniformed services.

A summary of the required FTE adjustments necessary to accomplish the aircraft 10-year plan are indicated in Table 4.1

Table 4.1 FTE Requirements to Accomplish Aircraft 10 Year Plan

	2003	2004	2005*	2006**	2007	2008	2009	2010	2011	2012
ORF (Aircraft Services)	92	102	114	114	125	125	125	125	125	125
PAC (Aircraft Replacement)	0	0	0	0	0	0	0	0	0	0
Total	92	102	114	114	125	125	125	125	125	125

* Additional WP-3D
** Additional High-Altitude Jet

Even though AOC currently is successful with retention and recruitment, the organization will be faced with issues resulting from an aging workforce. AOC currently employs 33.5 NOAA Corps officers who serve in program support related positions while also serving as pilots and navigators on NOAA aircraft (see Table 4.2). Of the 33.5 current NOAA Corps aviators, six were retirement-eligible at the end of FY02 and an additional 24 will be retirement-eligible or will have retired by the end of FY12. Of the current 60 government service employees, four were retirement-eligible at the end of FY02 and an additional 14 will become so by the end of FY12. In the next 10 years, a higher emphasis will need to be placed on the training of junior employees and instituting a formal program to transfer ground and flight knowledge and expertise.

Current FTE levels are inadequate for AOC to accomplish all tasked missions; hence, an increase in personnel (12 FTE's) is requested to maintain current capabilities (see Table 4.3). These additional personnel, particularly in the Science and Engineering Division, will create a more flexible and capable staff that can effectively design and install instrumentation necessary to accommodate NOAA's diverse data-acquisition requirements.

Projections of FTE increases above this base level are in response to line office requests for increased capability and are largely based on an increase in the number of NOAA aircraft as indicated (see Table 4.4).

Table 4.2 Current Human Resource Capabilities

AOC Division/Branch	Number NOAA Corps	Number GS FTE
Director's Office	5 *5 air crew	2 *1 air crew
Safety Staff (plus 1 Public Health Service Officer)	2 *2 air crew	
Programs and Projects Staff	3 *3 air crew	1 *1 air crew
Resource Management Staff		13
Operations Division	1 *1 air crew	1
Operations Division-Flight Branch	11.5 *11.5 air crew	
Operations Division-Maintenance Branch	3 *3 air crew	13 *12 air crew
Operations Division-Remote Sensing Division (Silver Spring, MD)	3 *3 air crew	
Operations Division-Snow Survey Program (Chanhassen, MN)	3 *3 air crew	
Science and Engineering Division		2 *1 air crew
Science and Engineering Division-Technical Branch		13 *10 air crew
Science and Engineering Division-Data and Development Branch	1 *1 air crew	15 *14 air crew
Total	32.5 *32.5 air crew	60 *39 air crew

*Indicates number of staff dual qualified as air crew

Table 4.3 Maintenance of Current Capabilities: Additional FTEs Required

AOC Division/Branch	Number NOAA Corps	Number GS FTE
Operations Division	4 *4 air crew	
Science and Engineering Division-Technical Branch		4 *4 air crew
Science and Engineering Division-Data and Development Branch		4 *3 air crew
Total	4 *4 air crew	8 *7 air crew

*Indicates number of staff required to be dual qualified as air crew.

Table 4.4 Increasing Current Capabilities: Additional FTEs required

Increased Capability	Number NOAA Corps	Number GS FTE
Airborne Technology Coordination		1 SED-Data and Development Branch (or NOAA Matrix FTE)
Increased Instrumentation Capability on All Aircraft		2 SED-Technical Branch *1 air crew
3rd Twin Otter		1 Ops Division-Maintenance Division (reprogramming of FTE)
Additional WP-3D	4 Ops Division-Flight Branch *4 air crew	2 Ops Division-Maintenance Division 3 SED-Technical Branch 3 SED-Data and Development Branch *7 air crew
Additional High Altitude Jet	3 Ops Division-Flight Branch *3 air crew	1 Ops Division-Maintenance Branch 3 SED-Data and Development Branch 4 SED-Technical Branch *7 air crew
Total	7 *7 air crew	20 *15 air crew

*Indicates number of staff required to be dual qualified as air crew.

Facilities Background and Future Requirements

Background

In October 1992, in the wake of Hurricane Andrew, Secretary of Commerce Ronald H. Brown formed an agreement with the USAF to move the NOAA Aircraft Operations Center from Miami International Airport to MacDill Air Force Base in Tampa, Florida. At that time, the MacDill AFB runway was scheduled to be closed as a result of the April 1991 recommendation from the Base Realignment and Closure Commission (BRACC). Based on this recommendation, the Air Force removed three squadrons of F-16 aircraft. In 1993, legislation reversed the flight-line closure ruling and allowed NOAA to transfer to MacDill AFB to utilize the runway. Other than a small Army fixed-wing detachment, NOAA was the only flying unit headquartered at the base.

MacDill's strategic location and outstanding airfield capabilities were highlighted in September 1994, when the base became a major staging area for Operation Restore Democracy in Haiti. MacDill AFB supported C-130 units from Texas, Arkansas, and North Carolina. In 1995, the BRACC decision to close the MacDill AFB runway to the Air Force was reversed; instead, the BRACC recommended keeping the MacDill flight line open and to relocate an active flying mission back to MacDill. To help ease the lack of refueling aircraft located in the southeast United States, the commission further identified the 43rd Air Refueling Group from Malstrom Air Force Base, Montana, along with its 12 KC-135 Stratotankers, to transfer to MacDill in October 1996. MacDill's host unit -- the 6th Air Base Wing -- was re-designated Oct. 1, 1996, as the 6th Air Refueling Wing under 21st Air Force and Air Mobility Command.

The 6th Air Mobility Wing is now the host command at MacDill AFB. Other tenant commands include the U.S. Central Command, the U.S. Special Operations Command, and the Joint Communications Support Element. The 6th Air Mobility Wing provides critical support to AOC (runway, base operations, security, medical care, etc.) that would otherwise need to be obtained under contract or by other means.

AOC is allocated the use of a large World War II vintage hangar as well as three additional buildings at no lease cost. In turn, NOAA is responsible for the facilities maintenance of these buildings, required utilities, and a portion of the overhead fees necessary to operate MacDill AFB. The aircraft hangar has 38,703 square feet of aircraft floor space, and can accommodate nearly all NOAA aircraft simultaneously. Additionally, the hangar door entrance is high enough to allow the tallest tail NOAA aircraft (WP-3D) easy entrance; however, it should be noted that this entrance is not high enough to allow entrance for a potential WP-3D replacement aircraft, the Lockheed C-130J. Due to instrumentation installation, aircraft maintenance, and protection from the harmful effects of heat and sunlight on the aircraft in Tampa, it is imperative that the aircraft based here be kept in aircraft hangars at all times.

The largest suite of office space at AOC is built into each side of the hangar. These spaces form the offices and laboratories of both the Science and Engineering Division and the Operations Division. The back (or street side) of the hangar houses the supply staff personnel, equipment, and supplies in a warehouse and office space constructed inside the hangar by AOC prior to its 1993 occupancy. The square footage of all office space in the hangar totals 21,503 and affords offices for 71 personnel.

A storage and facilities building (Bldg. 44) was constructed by NOAA in 1999 (occupied in 2000) and provides 4,000 square footage of floor space. In accordance with federal property regulations, this building was signed over to the Air Force after it was completed, but remains allocated to NOAA under the Space Occupancy Permit between the Air Force and the Department of Commerce. A diagram of the entire AOC facility is included in Appendix D.

In addition, NOAA utilizes another building (building 24) for AOC safety offices and the protection of ground equipment (aircraft tug, air conditioner truck, aircraft power unit, etc.) on the base flight line, adjacent to the hangar. This building provides 658 square feet of office space and 770 square feet of open, but covered space useful to protect the aircraft ground equipment from the elements. Due to Air

Force regulations addressing flight line security issues, this building may be destroyed in two years, which would force NOAA to look for comparable space elsewhere.

Finally, an AOC administrative building (building 9) composed of 4,496 square feet of office space and a conference room completes AOC facilities at MacDill AFB. This building also houses the auxiliary command post for the 6th Air Mobility Wing.

In summary, the aggregate square footage is deemed adequate for the 86 people presently assigned to AOC. The projected increase in FTEs outlined by this study suggests the need to acquire additional office space. This anticipated shortfall would be exacerbated by the potential loss of building 24 in 2004. The aircraft hangar is deemed adequate for the next 10 years.

Maintenance of Current Capabilities

At the current level of FTEs and aircraft, this facility is a tremendous asset to NOAA. Due to the age of the hangar, facilities maintenance problems have resulted in considerable expense to AOC. For example, AOC is renovating the bathrooms in the hangar at an estimated cost of $100,000 per restroom. This necessary renovation will be completed in phases because of the considerable cost. Additionally, the hangar roof will likely need replacement during this reporting period. Nonetheless, the lack of lease costs (estimated at $1.25M per year for a comparable facility) represents a substantial operational savings to NOAA. Further, the ancillary support services provided by the Air Force are outstanding.

Future Concerns

The host-tenant support agreement between the Air Force Air Mobility Command and the Department of Commerce for AOC is reviewed every five years and expires in April 2003. Recent communications with the 6th Air Mobility Wing Commander, Major General (sel.) Hodges, indicate that the Air Force may be reluctant to re-sign the standard five-year occupancy permit and will likely opt for an interim two-year agreement affording AOC continued operations at MacDill AFB through April 2005. This limited permit is due to increased demand for ramp and hangar space that may be required to support an increased number of Air Force aircraft at the base. The future Air Force plans at MacDill are unfolding at this time; AOC has been invited to participate in these discussions by the Wing Commander. Every effort will be made to accommodate both the increased Air Force and continued NOAA mission requirements.

If AOC is asked to vacate the present facility, indications suggest that the Air Force would invite NOAA to build a new hangar and office facility somewhere on the MacDill AFB property. In FY03, AOC will initiate a market analysis to determine the funding needed to either support this effort or move the entire operation to another location (as happened in 1993).

If building 24 is removed by the Air Force, and AOC's FTE count climbs slightly as projected, AOC will need to seek additional office floor space. This will result in a request to the Air Force to search for additional space on the base. A negative response will require AOC to either lease office space off base or build additional space by adding on to the hangar or building a second deck on top of building 9.

5.0 Technology Improvements

Airborne scientific instrumentation has been advancing with quantum leaps. In addition to replacing and upgrading its platforms, NOAA needs to address airborne platform technology upgrades and modifications to keep pace with emerging technology, regulatory requirements for navigation and communication systems, and new instrumentation.

Aviation Technology and Research Development

All NOAA line offices have requested that NMAO provide personnel to support data processing and technology development. At this time, NMAO does not have this capability in-house. In many cases, data processing and technical skills are in existence elsewhere within NOAA, the federal government, partnering academic institutions, and the private sector. NMAO proposes to establish a new GS position within the AOC Science and Engineering Division or a new matrix position with an already established FTE position within NOAA's Office of Oceanic and Atmospheric Research (OAR) to coordinate aircraft instrumentation and technology. This new FTE would track line-office data and technology needs, help individual programs acquire the needed expertise or support, coordinate instrumentation sharing programs, and maintain a current knowledge of technology advances that pertain to NOAA programs and services. Table 5.0 outlines all NMAO aircraft and instrumentation initiatives submitted in FY04.

Table 5.0 Aircraft and Instrumentation Initiatives Submitted by NMAO in FY04

FY04 Aircraft and Instrumentation Initiatives					
Aircraft	**Initiative**	**FY**	**Cost**	**Total**	**PAC/ORF**
G-IV	Instrumentation Upgrades	2004	4.600	**4.6**	**2004 PAC**
Turbo Commander	Turbo Commander Replacement	2004	1.750	**1.550**	**2004 PAC**
WP-3D	Inertial Navigation Upgrades	2004	1.645	**1.645**	**2004 PAC**
Required Regulatory ORF	Required Regulatory Upgrades	2004 ORF	0.307	**1.650**	**2004 PAC & ORF**
Required Regulatory PAC	Citation II Avionics Upgrades (PAC)	2004 PAC	1.343		
	Twin Otter Autopilot Upgrade (PAC)				
	Terrain Awareness and Warning System (PAC)				
	Head-up Display (HUD) for the NOAA G-IV (PAC)				
	Upgrade G-IV Avionics Suite (PAC)				
All	Scientific Instrument Maintenance	2004	0.500	**1.465**	**2004 ORF**
G-IV	Mid-Life Maintenance	2004	0.500		
All	Aircraft Maintenance	2004	0.465		

Table 5.1 outlines all NMAO aircraft and instrumentation initiatives submitted in FY05.

Table 5.1 Aircraft and Instrumentation Initiatives Submitted by NMAO in FY05

FY05 Aircraft and Instrumentation Initiatives					
Aircraft	**Initiative**	**FY**	**Cost**	**Total**	**PAC/ORF**
WP-3D	Cloud Physics Upgrade	2005	0.660	**2.037**	**2005 PAC**
WP-3D	Radiometric Temp & Fast-Response Humidity	2005	0.230		
WP-3D	Liquid and Total Water Upgrade		0.100		
WP-3D	Data Acquisition Display	2005	0.297		
WP-3D	AVAPS Improvement	2005	0.750		
Twin Otter N48	Air Chemistry Upgrades	2005	0.400	**0.400**	**2005 PAC**
Shrike, Turbo Commander	TAWS	2005	0.200	**0.575**	**2005 PAC**
Shrike N47	Mission Upgrades		0.125		
Citation	RVSM, EGPWS	2005	0.250		
WP-3D	Navigation Upgrade	2005	0.845	**0.845**	**2005 PAC**
Twin Otter	Twin Otter Standardization	2005	1.200	**1.200**	**2005 PAC**
Helicopter	Light Twin Helicopter	2005	9.000	**9.000**	**2005 PAC**
WP-3D	Additional WP-3D	2005	6.500	**6.500**	**2005 PAC**
WP-3D	Additional WP-3D O&M	2005	1.900	**1.900**	**2005 ORF**

G-IV Instrumentation Currently Installed	
Meteorological	
Hurricane Analysis and Processing System	Workstation accomplishes data analysis, processing, and message formatting Airborne Atmospheric Sounding Processing Environment (ASPEN) for dropwindsonde data processing
Total Temperature	Deiced Platinum Wire Resistor - Rosemount 102CP2AF and 102LJ2AG w/510GB41E amp Non-deiced Platinum Wire Resistor - Rosemount 102CL2AZ w/510GB35E amp
Dew Point Temperature	Chilled Mirror Hygrometer - Edge Tech (EG&G) 137-C3 Hygrometer w/137-S100 Sensor Cryo Hygrometer
Meteorological and Atmospheric Sensor Output	Two Data System Modules for instrument interface and data collection with 6 Networked Workstations
Airborne Vertical Atmospheric Profiling	Dropwindsonde Data System for drop execution, data collection and storage, Dropwindsonde Launch Chute, GPS dropwindsondes
Weather Radar	Collins WXR-700C C-Band w/ 30-inch antenna
Radiation	
Sea Surface Temperature	IR Radiometer (9.5-11.5 um) - Pyrometer Model PRT-5 w/AOC control unit
CO2, Air Temperature	IR Radiometer (14-16 um) - Barnes Model PRT-5 w/AOC control unit
Navigation	
Position (Latitude, Longitude), Ground Speed	2 Independent Inertial Navigation Systems - Honeywell Laseref II YG1779B Channel GPS Precision (Y Code) - Rockwell Collins 59J-1 Receiver

G-IV Instrumentation Currently Installed	
	2 Honeywell 12 channel GPS
Pitch, Roll, Heading	Wander Azmith Stable Platform Inertial Reference System - Honeywell Laserref II YG1779B
Static Pressure	Ps Transducer - Rosemount 1281AF2B1B
Dynamic Pressure	qc Transducer - Rosemount 1281AF2B1B
Angle of Attack Differential Pressure	Differential Pressure Transducer - Rosemount 1221F2VL7B1B
Sideslip Differential Pressure	Differential Pressure Transducer - Rosemount 1221F2VL7B1B
Angle of Attack Dynamic Pressure	Differential Pressure Transducer - Rosemount 1221F2AF8B1B
Sideslip Dynamic Pressure	Differential Pressure Transducer - Rosemount 1221F2AF8B1B
True Altitude	Radar Altimeter - Gould APN-232
Mean Sea Level Altitude	5 Channel GPS Precision (Y code) - Rockwell Receiver 3M
Communication	AF, VHF, UHF, ADF, Flight Phone, INMARSAT SATCOM and Passenger Communication System, Iridium SATCOM

G-IVSP Instrumentation Upgrades:

Enhanced Safety for G-IV

An FY04 budget initiative for $0.6M was submitted to purchase and install a head-up display (HUD) for the G-IV. NOAA operates the Gulfstream-IV in regions of the Atlantic and Pacific Oceans to provide data critical for forecasting hurricanes and winter storm tracks. The HUD provides pilots with an intuitive and comprehensive display of the aircraft state based on conformal symbology in the pilot's forward field of view. This display provides an increase in safety, situational awareness, and low visibility takeoff and landing capability on NOAA's G-IV aircraft.

The situational awareness of the pilot is enhanced by providing windshear awareness and recovery information, and more precise aircraft control and guidance during low visibility operations for takeoff and landing. Pilots can become qualified for lower minimums at CAT I/II facilities, and growth to CAT IIIa minimums. This enhanced capability can make the difference in mission accomplishment by expanding the number of available airports from which severe weather operations can be conducted.

G-IV Instrumentation Upgrades

NMAO will be receiving $8.4M in FY03 for G-IV instrumentation upgrades. See Appendix C for a detailed plan for use of those funds. NOAA requested $4.6M in FY04 to complete the upgrade of instrumentation aboard the G-IV. Improvements in the NOAA G-IV aircraft remote- sensing systems will enhance NOAA's hurricane-forecast capability. New technology will use remote sensors to develop three-dimensional profiles of hurricanes from 45,000 feet down to the surface and will provide forecasters with unprecedented real-time information on size and intensity. Also, radar-composite maps will provide critical rainfall information. This information is crucial to the forecast and warning process and is vital information for the emergency-management community for preparedness and evacuations.

Moreover, to improve hurricane-intensity forecasts of numerical guidance, next-generation hurricane-prediction models will require detailed information on the three-dimensional structure of the storm to improve model-storm initialization. Having a better description of the current storm in the models will substantially improve NOAA's ability to forecast more accurately the track and strength of a hurricane at landfall and the associated rainfall. This increase in model-prediction skill will increase lead times for evacuations and will enhance preparedness actions.

The proposed G-IV instrumentation upgrade is central to meeting the goals of the U.S. Weather Research Program's hurricane-landfall program. The instrumentation upgrade is the key component in improving numerical guidance to improve intensity forecasts by one-half a category (on the Saffir-Simpson scale) at 24 hours out and one category at 48 hours out with 95 percent confidence.

Appendix B outlines the plan for funding of $8.4M in FY03 and $4.6M in FY04. Specific scientific requests that will be considered for feasibility in this effort include:

1) Doppler nose radars system
2) Research quality Standard Instrumentation Package
3) High-speed standard and low-light digital videography
4) Workstations (plan to migrate all workstations to NMAO-supplied Linux system)
5) Data transmission upgrade (INMARSAT, Globalstar)
6) Stepped-Frequency Microwave Radiometer (SFMR)
7) Microwave temperature profiler (MTP – similar to instrumentation used on the NASA ER-2 and DC-8)
8) Differential absorption LIDAR (DIAL – similar to instrumentation used on NASA DC-8) for humidity and aerosol observations
9) Doppler LIDAR for clear-air wind measurements
10) Instrumentation for improved in-cloud/rain humidity measurements

The following requests will not be considered in the "Formal Name."

1) Addition of a scatterometer/profiler (VSDR/IWRAP) does not appear feasible at this time, because significant mounting issues make addition of this instrumentation to the G-IV cost prohibitive. However, the installation of Kuscatt is being considered.

2) A 12-channel GPS dropwindsonde system is not recommended until the next generation GPS sonde makes pre-launch procedures more streamlined.

WP-3D Instrumentation Currently Installed	
Meteorological	
State Variables	Sensors for the measurement of temperature, humidity, pressure, winds and fluxes
Cloud Particles	PMS 2-dimensional and 1-dimensional precipitation and cloud particle probes, PMS Forward and Axially scattering particle probes
	Aerosol sampling system
Radiation	Sea surface temperature radiometer
	CO_2 air temperature radiometer
	C-band and K_u-band scatterometers
	Eppley solar and terrestrial pyranometer and pyrgeometer radiometers
	Stepped Frequency Microwave Radiometer
Airborne Vertical Atmospheric Profiling	Dropwindsonde Data System for drop execution, data collection and storage, Dropwindsonde Launch Chute, GPS dropwindsondes
Sea Temp Profile	Airborne Expendable Bathythermographs (AXBT's) with 200-meter depth capability
Expandability	External Wing Store Station Mounts
Radar	
Weather Avoidance	Collins C-band nose radar
Horizontal	Lower fuselage C-band research radar – 360 deg. Horizontal fan beam
Vertical	X-band Doppler tail research radar
Wind Flux	Radome Flow Angle Sensors
Navigation	
Position Latitude, Longitude, Ground Speed	Dual INE and GPS Navigation Systems

WP-3D Instrumentation Upgrades:

WP-3D Avionics Upgrades

An FY04 Initiative was submitted for $1.645M to upgrade one of NOAA's WP-3D aircraft's navigation capabilities with up-to-date technology. The initiative will include purchase of Inertial/Global Positioning System (GPS) Inertial Navigation Units (INU), and interface with existing avionics. Replacement of some avionics and radios would also be required. Two complete systems plus spares would be purchased. Some customization of software and hardware would be required to interface with the aircraft research systems. Replacement of present INUs is deemed critical because current onboard units are repairable by only one known source (Litton Canada) due to age of units. New INUs require the replacement of the aircraft Junction "J" Box.

Upgrading the navigation systems will bring these aircraft systems up to current technology and improve aircraft reliability. The enhancement will make operations more efficient by improving the man-machine interface. Current navigation technology will also improve scientific data by increasing mesoscale spatial data acquisition (data resolution). In addition, the upgrade will make aircraft compliant with scheduled European and U.S. air traffic control navigation and communication requirements. Future avionics maintenance costs will decrease and aircraft reliability for tasking due to instrumentation reliability will be increased.

In July 2002, NMAO hosted a conference with the NAVAIR WP-3D Program Management Team to explore the latest avionics systems upgrades and options being investigated and implemented on derivative WP-3D aircraft in the Navy. The following list is of potential improvements and costs associated with these upgrades:

1) Navigation Systems:
   - Electronic Flight Display Systems (EFDS): Estimate $180,000 - $345,000
   - Replacement Inertial Navigation Unit (RINU): Estimate $70,000 - $135,000
   - LTN-72: Estimate $266-354K

   NOTE: The RINU is the Replacement Inertial Nav Unit package that is installed on Navy aircraft already equipped with the LTN-72 inertial units. As NOAA does not use LTN-72s, NAVAIR estimates $266K-$354K to install LTN-72s on each aircraft and modify our J-Box to integrate our systems. An additional $70-$135K is then required to upgrade to the RINU. Upgrade to RINU-G (GPS) would be an additional $125-140K.

2) Safety Systems:
   - Enhance Ground Proximity Warning System (EGPWS): Estimate $129,000 - $198,000
   - Traffic Collision Avoidance System (TCAS): Estimate $200,000 - $310,000
   - Protected Instrument Landing System (P-ILS): Estimate $35,000 - $47,000

3) Communications Systems:
   - 8.33 kHz VHF Communication: Estimate $70,000 - $111,000
   - Intercommunication System (ICS)

WP-3D Instrumentation Upgrades (Piggyback on G-IV Upgrade)

The following instrumentation design capabilities that are under consideration in the plan for G-IV instrumentation may be applicable to meeting scientific needs on the WP-3Ds:

1) **Doppler nose radars on both WP-3D aircraft**. The Doppler nose radar is under consideration as part of the G-IV upgrade and could be migrated to WP-3Ds for $200,000 - $300,000.

2) **Microwave temperature profiler (MTP) similar to the instrumentation used on the NASA ER-2 and DC-8).** Although this instrumentation is under consideration for installation on the G-IV, acquisition of MTPs would require a significant funding initiative. However, installation of existing instrumentation or newly acquired instrumentation on the WP-3Ds would be a very low-cost proposal.

3) **Differential absorption LIDAR (DIAL - like LASE on NASA DC-8) for humidity and aerosol observations**. NMAO has no current plans to procure this instrumentation to be added to the WP-3D standard configuration. However, a user-supplied down-looking version of this instrument could be supported on WP-3D with little effort. An up-looking port would require a longer timeframe for engineering design, analysis, and modification, as well as moderate funding support.

4) **Doppler LIDAR for clear-air wind measurements**. Instrumentation purchased for the G-IV could be mounted on a WP-3D as required.

5) **New flight-level data system (NCAR)**. This is in preliminary design stages and will be addressed as part of a G-IV upgrade. A WP-3D replacement will follow after the G-IV upgrade is complete and will be funded by an FY04 initiative.

Additional WP-3D Instrumentation Needs

NOAA WP-3Ds are heavily modified aircraft that are configured to support a variety of instrumentation packages. A recent survey of NOAA line office aircraft users indicated that the following upgrades to the WP-3Ds will be critical in the next 10 years.

The following upgrades requested by NOAA scientists are already in progress:

1) **Airborne Doppler radars with dual PRT capability on both WP-3D aircraft**.
This is an existing capability, and NMAO's Science Engineering Division (SED) is currently enhancing the Doppler processor system.

2) **Data transmission capability** (ASDL, INMARSAT, Globalstar).
This is a standard capability, and SED is systematically working on upgrades.

In an FY04 budget initiative, NOAA requested $1.46M for Cloud Physics System Upgrade ($660,000), Data System Standardization and Development for Heavy and Light Aircraft ($297,000), Liquid and Total Water Sensor Upgrades ($100,000), Upgrade of Aircraft Radiometric Temperature and Fast Response Humidity Sensors ($230,000), and AVAPS Dropwindsonde Reliability and Capability Enhancement ($173,000). ***This initiative is not projected to be funded in FY04.***

These improvements will greatly enhance NOAA's ability to collect in-situ measurements of cloud physics, ensure that current data collection capability is not lost due to un-maintainability of aging systems, add critical sea-surface temperature data to numerical models for storm intensity prediction forecasts, and allow for development of a universal data collection unit to more efficiently manage data collected by all of NOAA's aircraft.

Data from these systems are required to determine the in-situ characteristics of cloud types and local meteorological states for NOAA's Hurricane Reconnaissance and Research, Ocean Winds, Winter Storms, and Cloud Aerosol Research programs. The initiative will provide improvements in quality and quantity of data collected, with the most impact to programs in cloud physics characterization, data collection, and water measurement.

NMAO has already submitted funding initiatives in the FY04 budget process to support the following requests for system upgrades to the WP-3D aircraft.

1) **The cloud microphysics data package** is part of the standard configuration of the WP-3D. NMAO is redesigning the pylon that supports the system, and a data-system upgrade is planned with funding from an FY04 initiative. The APL spray flux spectrometer and update cloud microphysics instrumentation (i.e., HVPS, CIP) has been requested by NOAA scientists. The WP-3D is capable of supporting HVPS, which is currently user equipment. Supporting CIP would require a data-system upgrade that is planned with funding from an FY04 initiative.

2) Scientists from PMEL and ETL have requested an **upgrade to the suite of cloud and precipitation probe capabilities** to allow better resolution and faster electronics.
NMAO has addressed this request in an FY04 budget initiative that describes the need for continued replacement/upgrade of aircraft standard instrument suites.

3) New, cutting edge microphysics probes such **as Nevzorov total water content sensors and photographic cloud particle imaging sensors** were requested and are to be funded by FY04 PAC initiative.

4) Acquisition and installation of a new **microphysics data acquisition system,** which is more reliable, faster, and allows easier access to data after a flight, is also planned with funding from an FY04 initiative.

Dropwindsonde Capability Upgrade (Submitted with FY05 Budget Initiatives)

NOAA line offices supporting climate and weather services have requested that the WP-3D dropwindsonde capability be increased to an eight-channel GPS system. NMAO recommends investing in upgrading the sondes prior to upgrading the system. NCAR would require $400,000 to upgrade the sonde technology, and NOAA could provide partial or full funding for that effort. Once the sondes have been upgraded, the enhancement would cost $150,000 per system but would accommodate multiple expendables on eight-channels and would be smaller and lighter than the existing system. At this time, NMAO can support individual requests on a temporary basis for eight-channel capability using spare parts.

Improved Cloud/Rain Humidity Measurements (Submitted with FY05 Budget Initiatives)

A new probe pylon is currently being fabricated for the WP-3Ds, but the acquisition of improved probes will take a significant funding initiative of $400,000 and subsequent base funding for maintenance and calibration of $10,000 per year. NMAO is planning to forward an initiative in FY05 or FY06 to support climate and weather services.

High-Speed LAN and Satellite Phone Data Link

NESDIS has indicated that having all WP-3D data from on-board instrumentation available for transmission using a high-speed LAN and a satellite phone data link with the Internet would be a valuable tool for all NOAA users. The data link to the ground would facilitate uploading and downloading data from the aircraft and is expected to greatly enhance scientific experimentation. The link could be established at a baud rate of 128K. Total cost for two systems is $700,000. NMAO plans to draft an FY06 initiative to fulfill this program request. The issue of the funding of airtime should also be addressed, and NMAO suggests billing on a user-reimbursable basis.

DHC-6 Twin Otter Upgrades:

Twin Otter Avionics, Electrical System and Airframe Standardization Package (Submitted with FY05 Budget Initiatives)

NMAO is submitting an FY05 budget initiative for $1.2M to standardize NOAA's Twin Otter flight decks and provide identical mission support capabilities to 95 percent of NOAA's programs. NOAA currently operates two Twin Otter aircraft and is in the process of acquiring a third Twin Otter. The third will be purchased outright in 2003. Each Twin Otter acquisition involved purchasing a used aircraft, equipped for the previous owner, that required several modifications to support NOAA missions. NOAA missions require modifications to the Twin Otter airframe and interior, including interior configurations that are easily modified, data collection ports through the airframe, two-way communications between the flight crew and scientific crew during the flight, connection of the scientific crew with radio and satellite communications, power and data distribution points throughout the cabin, and increased fuel carrying capacity. Additionally, for safety, training, and standardization, the types, location and capabilities of the instrumentation and communications equipment should be as identical as possible. This initiative will make the three NOAA Twin Otters identical for the flight crews and 95 percent of NOAA's users. One of NOAA's current Twin Otters has special modifications to support air chemistry missions that make up the five percent that will not be supported by all three Twin Otters.

These improvements will greatly enhance NOAA's ability to collect in-situ measurements in support of NOAA's National Marine Fisheries Service (NMFS) and National Ocean Service (NOS) missions by allowing various labs and offices to standardize their techniques and interfaces between the aircraft and their unique data-collection systems.

This initiative benefits all NOAA programs by reducing the complexities and expenses related to:

- maintaining several data integration packages
- standardizing training
- data comparisons from data obtained by more than one Twin Otter

1) **High Frequency (HF) Radio** – HF radio communications allow effective radio communications during offshore flights in support of NMFS right whale and marine mammal surveys. NMAO currently has HF radios for two Twin Otters, and the third HF radio is included in an FY05 budget initiative.

2) **Intercom System** – All NOAA users have requested the ability to have the scientific mission crews communicate on radios, on satellite phones, with each other and with the flight crews. NMAO has worked with Twin Otter users to design a flexible intercom system that will support their requirements; one is currently being installed in a single Twin Otter. NMAO included intercom systems for the remaining two Twin Otters in an FY05 budget initiative.

3) **Weather Radar** – Color weather radar is critical in conducting flights in support of NMFS and NOS. NMAO currently has color weather radars installed in two Twin Otters; the third color weather radar is included in an FY05 budget initiative.

4) **Remote Sensing Ports** – NOS and NMFS make use of overhead and belly ports for conducting remote sensing and marine mammal surveys. NMAO has modified two Twin Otters and included the third Twin Otter in an FY05 budget initiative.

5) **Inverters** – NOS and NMFS missions require AC power distributed to the workstations throughout the cabin. NMAO currently has inverters installed in two Twin Otters; the inverters for the third Twin Otter are included in an FY05 budget initiative.

6) **Alternators** – 28 volt 250 amp alternators are required to support the additional power requirements. NMAO currently has larger alternators installed on two Twin Otters; the alternators for the third Twin Otter are included in an FY05 budget initiative.

   An enhanced power distribution system (increased KW@110 VAC and 130 A VDC) through an intelligent load shedding arrangement on all three Twin Otters has also been requested by the OAR community.

7) **Precision Radio Altimeters** – NOS and NMFS require precise vertical navigation with the ability to capture the information to their data systems. NMAO has installed precision radio altimeters on two Twin Otters; radio altimeters for the third Twin Otter is included in an FY05 budget initiative.

8) **Multiple Band Radio** - NOS and NMFS have a requirement to communicate with vessels over marine, UHF and VHF frequencies. NMAO currently has a Wolfsburg multi-band radio installed in one Twin Otter and will use an FY05 budget initiative to add this capability to the two remaining Twin Otters.

9) **Autopilot** – The current autopilot is no longer supported and is incapable of supporting the precise navigation and system interface that is required to support NOS and NMFS missions. NMAO has

upgraded the autopilot on one Twin Otter, submitted a FY04 budget initiative for a second autopilot, and will use an FY05 budget initiative to upgrade the third Twin Otter.

10) **Bubble windows** – Several NOS and NMFS missions require the observers to monitor the area beneath the aircraft and to make accurate measurements regarding the location of the intended target. NMAO installed bubble windows on two Twin Otters, and included bubble windows for the third Twin Otter in an FY05 budget initiative. In addition, larger aft bubble windows have been requested by scientists conducting fisheries surveys and science.

11) **Satellite communications** – NOS and NMFS missions require the ability to communicate in areas of limited radio coverage and with ground-based activities. NMAO is including three satellite communications systems for the Twin Otters in an FY05 budget initiative.

12) **Global Positioning System (GPS)** – NOS and NMFS missions require precise navigation, navigation data output to cabin data collection systems, and the flexibility to operate from remote airfields that may only have GPS approach capability. NMAO is currently upgrading one Twin Otter in FY03 and has included GPS systems for the other two Twin Otters in an FY05 budget initiative. Scientific users have also requested moving map GPS capability for all Twin Otters.

13) **Aircraft Traffic Warning System** – NMAO is installing aircraft traffic warning systems in all its aircraft to enhance safety and situational awareness for the flight crew. Two of the Twin Otters will have these systems installed in FY03 and the third Twin Otter is included in an FY05 budget initiative.

Enhanced Safety for Twin Otters-Autopilot Upgrade (Submitted with FY04 Budget Initiatives)

An initiative was submitted in the FY04 budget process to provide for $0.3M to upgrade the autopilot systems in one Twin Otter. NOAA operates two Twin Otters manufactured in 1980. Most of the avionics on the aircraft are factory original. The autopilot in N48RF was replaced in 1999. The original autopilot is still in N57RF, is no longer made, and parts are not readily available. It has been difficult to find qualified technicians to service this unit; it will no longer be serviceable in the near future as the supply of parts is exhausted. An upgraded autopilot will permit continued utilization of the Twin Otter to its full potential. A new unit will allow for extended operation at the low level, over water flight regimes required for marine mammal surveys.

Air Chemistry Upgrades to Twin Otter N48RF (Submitted with FY05 Budget Initiatives)

Twin Otter N48RF is already extensively modified for OAR's Air Resources Laboratory (ARL) needs. ARL plans to continue to use this platform and will require additional modifications throughout the next 10 years as technology develops. With the exception of a planned redesign of the external power bus to prevent periodic interruptions of scientific power during handoff from a ground power unit to aircraft generators, the following requests for modifications will require additional funding:

1) Modified wing hard points to allow the installation of laser spectrometers for real-time particle measurements. This modification would benefit all other users.

2) Acquisition of FSSP, PCASP, and two DC probes and installation of associated cabling throughout the aircraft wings. NMAO estimates that each probe will cost $40,000, the date system will cost approximately $10,000, and cabling for each probe will cost $5,000.

3) Installation of the Best Aircraft Turbulence (BAT) probe on an aircraft nose boom. This instrument has been installed on the WP-3D, but installation on the Twin Otter will require additional engineering and fabrication support from NMAO.

NMAO will initiate an FY05 PAC initiative jointly with OAR to fund the upgrades to Twin Otter N48RF. In addition to the one-time PAC funds, maintenance, installation and calibration of this equipment will cost NMAO an additional $10,000 each year.

Upgrades to Light Aircraft Avionics Required by FAA Regulation (Submitted with FY04 Budget Initiatives)

An estimated $250,000 is needed for Required Regulatory Upgrades to the Citation II Avionics Suite. For the Citation II to accomplish the assigned mission in both the Atlantic and the Pacific, it must undergo several avionics upgrades. These upgrades will allow the Citation II to: 1) comply with new regulatory requirements to operate in a Reduced Vertical Separation Minimums (RVSM); 2) operate an Enhanced Ground Proximity Warning System (EGPWS); and 3) upgrade the radio frequency capabilities to meet the new standards.

1) The Citation II must be certified for RVSM airspace. RVSM airspace is between 29,000 feet (flight level 290) and 41,000 feet (flight level 410), inclusive, wherein aircraft are separated by 1,000 feet vertically rather than the standard 2,000 feet. Gaining approval for conducting operations in RVSM airspace is a two-part process. First, the aircraft must be approved by the FAA. Second, the flight crews must be trained in RVSM-specific procedures. RVSM aircraft airworthiness approval is granted from FAA for the Citation II when the aircraft a) is outfitted with specified avionics altimetry and altitude alerting systems; b) has documented the accuracy and integrity of such systems; c) has documented the affects of flight operating systems on static source error throughout the aircraft's

flight envelope; d) has documented engineering data to ensure continued in-service RVSM integrity; and e) has submitted a maintenance inspection program that provides for continuous airworthiness approval. There are limited sites and processes by which to measure the altimeter and altitude alerting system that can include extensive system calibration. RVSM certification costs are for the service to document, calibrate, validate, and train flight crews for the Citation II.

2) EGPWS is required for mandatory FAA airworthiness certification by March 2005 on the Citation II. EGPWS provides numerous visual and aural advisories and warnings to prevent inadvertent flight into the ground, controlled flight into terrain, excessive descent rates, excessive terrain closure, altitude loss after take-off, unsafe terrain clearance, excessive glide slope deviation, descent below selected decision height, and excessive bank angle. It consists of an EGPWS-integrated computer system that receives inputs from the radio altimeter, digital air data computer, glide slope receiver, landing gear handle, and flap system.

3) Radio frequencies in the VHF communication band (118-137 MHz) are fully saturated in many areas. Various measures were taken to relieve the channel congestion not requiring system changes. However, an evaluation of the problems concluded that a split from the present 25 kHz channel bandwidth to 8.33 kHz is currently the only available solution to satisfy in time the expected growth. This conclusion was endorsed at the (1995) International Civil Aviation Organization divisional meeting, and Europe was the first to implement the plan for 8.33 kHz spacing beginning 1 January 1999.

NOAA's missions on the Citation II require flights in airspace controlled by both the Federal Aviation Administration (FAA) domestically and the International Civil Aviation Organization internationally. Failure to comply with the existing and future regulations may restrict the Citation II from operating in airspace critical to its coastal oceanography and hydrography remote sensing and weather-related missions.

An estimated $625,000 is needed to install a Terrain Awareness and Warning System (TAWS) in the two Twin Otters, two Shrike Commanders and the Turbo Commander. Aircraft operations in support of NOAA programs, especially fisheries surveys, air chemistry, and coastal oceanography, are frequently conducted at low level over land and water in severe weather and in areas of reduced visibility. TAWS will increase the overall safety of the aircraft and crews. TAWS is required for mandatory FAA airworthiness certification by March 2005 on these aircraft. It provides numerous visual and aural advisories and warnings to prevent inadvertent flight into the ground, controlled flight into terrain, excessive descent rates, excessive terrain closure, altitude loss after take-off, unsafe terrain clearance, excessive glide slope deviation, descent below selected decision height, and excessive bank angle. It

consists of a TAWS-integrated computer system that receives inputs from the radio altimeter, digital air data computer, glide slope receiver, landing gear handle, and flap system.

Infrared Sea Surface Temperature (SST) Sensors in Light Aircraft

Line offices supporting fisheries surveys and science and coastal oceanography use infrared sea-surface temperature sensors in the Twin Otters and Shrike Commanders. Users have requested that NMAO provide SST sensors as a standard part of the aircraft configuration. As more users are requiring this type of data, a cost-effective approach would be to outfit both Twin Otters and Shrike Commander N47RF with the sensors, along with the data-collection system to standardize data collected throughout NOAA.

AC-500S Shrike Commander Upgrades:

Mission Upgrades to Shrike Commander N47RF (Submitted with FY05 Budget Initiatives)

With modernization and system upgrades, both Aero Commanders should remain in service for this 10-year period and provide continued flexibility towards meeting NOAA's light aircraft mission requirements.

Throughout the nearly 20 years of service to NOAA, this aircraft was used almost exclusively to support the NOS Aeronautical Charting Division's Flight Edit mission, and it was modified and optimized to perform that specific mission. Modifications included a camera hatch with a hydraulically operated door, and a vacuum line to support a precision photogrammetric camera. In 1999 the Flight Edit mission was transferred to the FAA, along with the aircraft itself.

In FY02 the aircraft was transferred back to NOAA, where it will clearly provide low-cost capabilities for diverse mission support with a multitude of instruments. Requests for time on this aircraft in FY03 have already been received from OAR and NMFS as well as from and non-NOAA partners, the FAA and Naval Research Laboratory. The FAA request is for support of the Flight Edit mission once again.

NMAO recognizes the need to convert N47RF from a single-mission platform to a multi-mission-capable platform. Hyperspectral modeling, photogrammetry, fisheries surveys, and marine sanctuary coastal surveys are projects that have already been scheduled for FY03. Additional capabilities could easily include LIDAR for coastal oceanography, damage assessment surveys, and pilot instrument training.

One possible disruption to service could arise from a requirement to replace the spar cap in N47RF within the next 10 years. At present there is no indication that a spar cap replacement will be required on N47RF, and it is currently on a 30-month inspection cycle for spar cap corrosion. However, approximately 75

percent of the Aero Commander fleet has required a spar cap replacement, at an average cost of approximately $150,000 and four months downtime.

Urgent upgrade and maintenance concerns	Estimated Cost
Extensive maintenance is required on N47RF to correct several years of neglect prior to and during the period of transfer to the FAA. During this period, the aircraft was unused and virtually no basic maintenance was performed. Consequently, areas of corrosion and paint must be addressed immediately.	$35K
GPS receivers (with annual database renewal subscriptions) with IFR certification for enroute, terminal, and approach procedures and navigation, integratable with the autopilot system and a multi-function display. (a)	$10K
Upgrade Autopilot w/ GPS compatibility, roll steering, and altitude select (b)	$80K

(a) The currently installed GPS receivers in both aircraft are outdated, no longer in production, and no longer supported by their manufacturers. In addition, the current receivers are not approved for IFR enroute, terminal, and approach-phase navigation. GPS approaches are being designed for hundreds of small airports, but our aircraft that operate from these fields do not currently have the capability to use those GPS approaches. Modern receivers are available that will fit in the panel space of the existing units, and will provide compatibility with other upgrades and enhancements (such as upgraded autopilots and multi-function displays) to follow. Replacement units must have GPS position/data-out capability. This requirement for GPS data output is of particular immediate concern in N51RF; the snow survey program is ready to go online with a stand-alone moving map survey system that requires an NMEA data output stream not available from the antiquated Trimble unit.

(b) The current autopilot system in N47RF is limited in its ability to maintain a precise heading and altitude. This system uses a rate-based error correction that requires a significant amount of error before any correction is made. Furthermore, the system is not able to retrim the aircraft when changes are made in airspeed. As many surveys require airspeed changes, the autopilot must be disengaged and the aircraft retrimmed each time a new line is begun. This causes a diversion of the pilot's attention at a critical time. Also, the accuracy and reliability of the current autopilot system make it less than ideal for survey operations. A more accurate autopilot system with better functionality will provide a significant enhancement in survey capability. Data analysis from a recent hyperspectral modeling mission shows that the autopilot's inability to hold a steady course and altitude has left data holidays and increased data processing time to remove fluctuations in heading and altitude during data collection.

General Upgrades to Both Shrike Commanders (Submitted with FY05 Budget Initiatives)

To continue serving NOAA into the future, additional investments in both aircraft will be required. Specifically, three areas need to be addressed:

1) Advances in technology that will enhance safety, economy, and versatility need to be incorporated.

2) Proposed FAA regulations will require several modernization upgrades to the general aviation fleet during the next 10 years, but as of today the only known upgrade that will be required of this size aircraft (fewer than six passenger seats) will be 8.33 kHz radio frequency spacing.

3) N47RF must be converted from a one-mission platform to a multi-mission platform.

Shrike Commander (AC-500) Equipment required for standardization goals, regulatory requirements, and multi-mission capability	Area of addres s1, 2, 3	Currently installed in N47RF	Currently installed in N51RF	Cost per Aircraft ($K)
Dual HSI instruments so plane can be safely flown from either flight station (a)	1		X	$10
Multi-function displays with the capability to overlay weather radar, collision avoidance, terrain awareness, navigational aids, and programmed flight path on a single unit visible to both pilots.(b)	1,3			$80
UHF and marine band radios (c)	3			$10
Data output of state variables to scientific work stations (d)	3		(d)	$20
Digital Engine Analysis System (e)	1			$10
Digital Fuel Gage / Fuel Computer (f)	1			$10
Moving map display (g)	1,3		(g)	$20
Noise canceling headsets for crew & passengers (h)	1,3		X	$3
Removable photo window (i)	3			$10
Replace rear bench seats with folding web seats (j)	3			$20
Nadir video camera mount (k)	3		X	$10
Digital datalink (l)	1,3			

(a) Currently, N47RF has only one HSI and one RMI installed. To make this aircraft a better dual-pilot IFR platform, dual installation of these instruments is required. Electronic gauges that combine the functionality of both HSI and RMI instruments are readily available for approximately the same cost as a mechanical HSI. Combining these two gauges would have an added benefit of allowing the pilot's side turn and bank indicator to be moved to a more visible location on the panel. The existing HSI and RMI instruments on the pilot side can be moved to the copilot side. Providing an HSI and an RMI to the copilot will increase dual-pilot safety in the aircraft.

(b) Multi-function display systems provide a number of safety- and mission-related advantages in one location. These units provide navigational information on a moving map display but also overlay traffic, terrain and weather data with the navigation display. The end result is a focal point of information all clearly displayed in relation to the aircraft's position over the ground. The result is enhanced safety and improved mission capability.

(c) During certain missions, the ability to communicate directly with military aircraft and facilities provides increased safety and better mission coordination. In addition, the ability to communicate with surface vessels is essential to other missions. Either a single UHF radio and a single VHF-FM radio can be installed or a multi-band radio that incorporates these bands with the aviation VHF band should be installed.

(d) A common research requirement for many of our missions states that variables should include static air temperature, static air pressure, airspeed, and altitude. In N51RF the static air temperature and radar altimetry data are available through the existing snow-survey data port connector, but a static air pressure transducer is part of the snow-survey data acquisition hardware as this variable is not available as a common aircraft output.

(e) Although the current factory-installed analog engine gauges in N47RF are adequate, available new technology that represents a quantum leap in capability should be explored. Digital engine analyzers can precisely record and indicate the cylinder head temperature for each individual cylinder. The current analog gauges provide a relatively inaccurate measurement in one cylinder only. In addition, they provide a precise digital indication of exhaust gas temperature that allows the optimization of engine fuel mixture leaning. These gauges provide a means with which to identify and diagnose minor problems with engine cylinders prior to their becoming major problems (or complete failures). Over time, these gauges pay for themselves in two other ways. They provide a means to optimize fuel economy and they allow for increased engine life. (Many problems associated with reciprocating engines can be traced to improper fuel mixture management.)

(f) The current factory-installed, analog fuel gauge is relatively inaccurate. This gauge can be replaced with a digital gauge that incorporates increased accuracy and expanded functionality. Furthermore, this unit can fit in the exact same space as the current fuel gauge. Benefits include precise fuel management and automatic fuel calculations. This also provides a diagnostic tool to identify discrepancies in engine fuel-flow rates. Combined with a digital engine analyzer, this provides a powerful tool for maintaining these aircraft engines in top condition. This may result in increased maintenance savings and will result in increased safety.

(g) Moving map GPS systems provide a major improvement in situational awareness. Furthermore, they make it possible to quickly and easily view proposed survey track lines overlaid on special-use airspace to determine possible conflicts. It is common for this function to be integrated with a multi-function display for enhanced situational awareness. However, the capabilities of survey-quality systems are a step above the more common avionics installations, and such systems will be requisite for the accomplishment of NMAO's survey missions. The snow survey program currently uses a survey trackline display as part of its data acquisition system, but this functionality should be available in the aircraft for the use of all missions supported by the Shrikes.

(h) Noise-canceling headsets that provide the highest level of hearing protection should be available at all crew member stations.

(i) A study should be undertaken to determine if a modification could be made to these aircraft that would allow for a removable photography window to replace one of the aircraft cabin windows. This would bring the aircraft toward commonality with the NOAA Twin Otter aircraft and allow them to be utilized more effectively on marine mammal surveys.

(j) The bench seat currently installed in N47RF is better suited to executive transport than scientific data collection. While very comfortable, the seat is large and heavy. A seat that takes up less cabin room and adds less weight to the aircraft would be preferable. Furthermore, due to the location of the cabin door, the seat blocks access for installation or removal of scientific gear. This was not an issue when the aircraft was a single-mission platform and rarely required reconfiguration. As a multi-mission platform, a foldable seat that allows for easier loading and unloading would be a significant enhancement. When flying the snow survey mission, N51RF does not carry its rear bench seat, but a lightweight folding seat should still be available for other missions in this aircraft.

(k) For photographic operations, a downward-looking camera coupled to a small video screen within the pilot's instrument scan could be very helpful in lining up and ensuring coverage over photographic targets. N51RF and N53RF already have downward-looking camera modifications and this capability will move N47RF into closer commonality with them.

(l) The FAA will soon transition from analog voice to digital datalink communication to reduce radio congestion and facilitate significantly more data transfer than is currently available via voice radio. Air-to-ground, ground-to-ground, and administrative communications will integrate into a digital telecommunications system, enhancing operational safety and efficiency.

The following specific requests for data processing or technology upgrades have been made by NOAA line offices.

1) **Full support for the processing of turbulence measurements from the gust probe system on the WP-3Ds to assist with climate and weather services.** The SED is working on an in-house improvement to the data system that would allow collection of data at a higher speed. However, the processing to provide turbulence data could be accomplished through a partnership with a NOAA laboratory, such as OAR's Field Research Division (FRD), which has expertise to develop an onboard processing package.

2) **Full provision of meteorological data (temperature, humidity, and wind fluctuations) rather than just direct outputs in engineering units from the gust probe system.** A standard data-processing module developed through a partnership with a NOAA, government, university, or private-sector laboratory that has the expertise to design and fabricate the package would provide processed data. The data-processing system could be exported to partner agencies to standardize climate and weather data across the federal government.

3) **NMAO support for the continued development of LIDAR technology for biological applications and remotely based salinity sensors to assist programs focused on fisheries science and surveys, coastal and blue water oceanography, and climate and weather services.** NMAO suggests using partnerships with NOAA entities, other agencies, and academic institutions that already have in-house LIDAR expertise.

4) **Expansion of photogrammetry and remote-sensing tools available for use on the Twin Otters and Shrike Commanders**. NMAO suggests using partnerships with NOAA entities, other agencies, and academic institutions that already have in-house photogrammetry and remote-sensing tools and expertise.

5) **Development of new sensor packages, sampling software, and data-collection systems on light aircraft.** A standard data-processing system and sensor package developed for heavy aircraft could be scaled for use in light aircraft (contract and in-house) through partnerships with other line offices. The FTE in the new position could provide guidance and leadership to light aircraft users during this process.

6) **Development of aircraft capabilities for radio tracking of tagged marine mammals.** NMAO suggests using partnerships with NOAA entities, other agencies, and academic institutions that already have in-house tracking tools and expertise.

7) **Development of a range of remote-sensing technologies for use in NOAA and contract aircraft.** Across line offices, scientists have indicated that development of a range of remote-sensing technologies, such as LIDAR, airborne fish detection technologies, multispectral scanners, and SEAWIFS is an emerging need for NOAA programs supporting fisheries surveys and science, coastal and blue water oceanography, and climate and weather services. Immediate data-collection needs include sea-surface temperature, ocean color, water opacity, salinity, and wave height. NMAO currently has the engineering capability to design and analyze instrumentation mounts for all light aircraft. With an FTE dedicated to airborne technology coordination, NMAO could coordinate the development of light aircraft technologies for use by NOAA on in-house assets as well as contract or partner assets.

Future needs identified from heavy aircraft workshop in July 2000:

A number of the mission profiles demonstrated a need for new instrumentation and operational capability over the next five-10 years. The instrumentation needs include, but are not limited to:

- Improved measurements of moisture in the atmosphere from the surface to the tropopause. This capability will require improved in-situ humidity and moisture variable measurements at temperatures from +30°C to -50°C. The capability of dropsondes may be greatly improved by the addition of passive microwave remote-sounding equipment.

- Improved capability to remotely map the precipitation and wind fields in convective storms with temporal resolution of a few minutes through the addition of a rapid-scanning Doppler radar and polarimetric microwave imaging radiometers.

- Improved capability to remotely map the microphysics fields in convective storms through the addition of polarization diverse radars.

- Improved capability to remotely map the wind fields where there are no precipitation targets, both in the pre-convective environment and near convective storms, through the increased sensitivity of the X-band tail radar and the addition of Doppler LIDAR and polarimetric microwave imaging radiometers.

- Improved capability to map the cloud-top and cloud-base fields through the addition of vertically pointing LIDAR.

Another area that, according to all of the mission profiles, needs attention is improved telecommunications within the aircraft, between the aircraft and the ground, and from aircraft to aircraft. Research needs mentioned were the addition of an onboard local-area network and server to connect all of the instruments together on the aircraft. Additionally, both research and operational mission profiles required improved broadband telecommunications (>9600 baud) between aircraft, and between the aircraft and the ground. It is expected that digital INMARSAT links will be able to satisfy the mission bandwidth requirements.

Finally, a couple of mission profiles expressed the need for access to unmanned and remotely piloted aircraft (UAV, RPV) to operate in environments unsafe or inaccessible to manned aircraft Given the lack of NOAA experience with UAV and RPV platforms, it was felt that NOAA needs to partner with other agencies or private-sector entities that are using these platforms, and to alert them to NOAA's requirements and needs.

Program Requests – Unaddressed Issues:

Due to time and budgetary constraints, requests that did not serve a wide user base were not addressed specifically in this plan. The following requests will be addressed on an individual user-funded basis:

1) **Aircraft-towed sensor package capability**. The WP-3Ds have accomplished projects using trailing cones, but NMAO has not supported towed-sensor packages. An actual aircraft-towed sensor package capability will require time for design and analysis and a relatively small amount of funding for installation. NMAO is available to discuss this issue with users that require this type of technology.

2) **UMASS ocean-surface current imager capability.** The WP-3Ds currently have the capability to support this instrumentation if the imager can be mounted in a WP-3D down-looking port. NMAO is available to discuss this issue with users that require this type of technology.

3) **95 GHz radar for sea-spray concentration and velocity.** The WP-3Ds currently have the capability to support this instrumentation if the imager can be mounted in a WP-3D down-looking port. NMAO is available to discuss this issue with users that require this type of technology.

4) **Hurricane Research Division Stepped-Frequency Microwave Radiometer (SFMR).** One system is already on order with funding from the Office of the Federal Coordinator for Meteorology, but subsequent support systems will require significant funding to adequately utilize the system. To fully maintain the scientific objectives of line offices providing climate and weather services, three to four systems need to be maintained in-house. Each system costs $120,000 plus a total of $30,000 a year for all systems for repairs, preventative maintenance, and calibration. NMAO anticipates receiving funding through OFCM for the acquisition of systems.

5) **Airborne expendable ocean probes (AXBT, AXCP, AXCTD, Sonobuoy).** AXBT's are currently supported by NOAA WP-3Ds, but the utilization of other type probes would require user-provided data collection and recording equipment. NMAO plans to invest in the development and acquisition of eight-channel GPS receiver technology to support mini-AXBT and dropwindsondes.

6) **Better radiometric observing capabilities for satellite calibration and validation.** NMAO is available to discuss this issue with users who require this type of technology in support of climate and weather services.

7) **Installation of the SCRIPPS laser-wave height altimeter and digital-wave imaging system on the WP-3Ds.** The WP-3Ds currently have the capability to support this instrumentation if the imager can be mounted in a WP-3D down-looking port. NMAO is available to discuss this issue with users who require this type of technology.

8) **24-Hour Operational Capability on the WP-3Ds.** Both NWS and OAR have identified several projects that may require 24-hour capability on the WP-3Ds. NMAO will have to address these during the scheduling process on a case-by-case basis. Depending on the requirements of the mission, additional FTEs or platforms may be required. Long-term, reliable 24-hour operational capability on the heavy aircraft will require 'n+1' resources; e.g. WP-3D operations-from a single base requires two WP-3Ds and three crews.

9) **NMAO provision of all expendables (GPS dropwindsondes and ocean probes).** NMAO does not have the funding level to provide all expendables for use on the WP-3Ds and G-IV in support of NOAA programs. NMAO will continue to maintain a stock of expendables for small-quantity users on a cost-reimbursable basis.

10) **Positioning of a high-wing survey/photogrammetry platform on the West Coast for fisheries science and surveys.** NMAO will address the use of the Twin Otter or Shrike Commander on the West Coast each year during the scheduling process. In an effort to maximize the utilization of the aircraft and better service NOAA requirements on the West Coast, NMAO will focus on providing line offices with economic alternatives during the scheduling process.

11) **Increased requirement for a second Twin Otter or similar aircraft for annual right whale surveys along the East Coast.** NMFS anticipates the need for a NOAA Twin Otter full time on an annual basis for right whale surveys plus a second similar platform for four months a year during the summer. By FY06, a second platform will be needed on a full-time basis. At this time, the Twin Otter schedule would not allow for this type of commitment. NMAO suggests evaluating the Shrike Commander for feasibility for this program on a short-term basis and evaluating the feasibility of acquiring an additional Twin Otter. Another option is to initiate a study to find a type aircraft that could eventually replace the Twin Otters at the end of their useful life. Contract services were attempted in FY99, but NOAA aircraft use was found to be more cost effective and reliable.

12) **Small, high-wing single-engine aircraft for coastal pinniped surveys along the Northeast coast and Alaska.** NMFS has indicated that the need for coastal pinniped surveys will be increasing each year through the next 10 years. NMAO recommends considering the Shrike Commander or a contract aircraft service provider for cost effectiveness for these fisheries surveys.

13) **Aircraft similar to a Twin Otter for Alaska marine mammal surveys for 300-350 hours a year.** During the annual aircraft scheduling process, requests for the NOAA Twin Otters should be evaluated against contract aircraft providers using safety, reliability, and cost effectiveness as a basis of evaluation. On a long-term basis, the acquisition of a fourth Twin Otter or an evaluation of another type platform should be initiated if NOAA aircraft are preferred to contract aircraft services.

14) **Increase requirements by OAR for the NOAA Twin Otter N48RF.** N48RF has been modified as a one-of-a-kind support platform for air chemistry projects. The needs of OAR should be addressed during the annual scheduling process and be based on line office priorities.

15) **Small twin-engine aircraft for near-shore surveys.** NOAA line offices supporting fisheries surveys and science, coastal oceanography, and climate services have indicated that a smaller twin-engine platform for near-shore surveys of at least four hours and capable of carrying three to four scientists would be an economical augmentation to the NOAA fleet. Currently, both Shrike Commanders have these capabilities and could be scheduled during the annual aircraft scheduling process to meet NOAA needs. Requests that are not met using the NOAA Shrike Commanders should be contracted using consultation with NMAO.

16) **NWS Snow Survey Instrumentation Replacement and Upgrade.** The two existing gamma radiation detection systems currently used by NWS in the Turbo Commander and Shrike Commander N51RF will need to be replaced within the next five years, as replacement parts are difficult to find or are unavailable. In addition, the snow survey program is requesting that a passive/active microwave sensor be installed and tested on both snow survey platforms for simultaneous airborne gamma radiation data collection. NMAO will support any initiatives submitted by NWS to accomplish these requirements.

17) **Instrumentation Support for NOAA Research Light Aircraft Programs.** The Air Resources Laboratory requires continued support for instrumentation and demodification of Twin Otter N48RF three weeks prior to project start date and up to one week after project end date due to the retirement of ARL personnel. If ARL is willing to switch to a standardized data system, NMAO will have the capability of fully supporting this request. Otherwise, NMAO can help with manual labor but will not have the expertise to fully support the ARL-specific instruments. ARL also requests periodic accessibility to N48RF for instrument-testing purposes outside of scheduled project dates. This request can be accommodated on a case-by-case basis, as long as the aircraft is not assigned to support another user. Specific requests for instrument testing can be submitted during the annual aircraft scheduling process.

18) **Office of National Marine Sanctuaries Request for Turbo Commander Support in the NW Hawaiian Islands.** NMAO has conducted a preliminary study of this request and recommends a combination of contract, partner agency, and in-house aircraft support to satisfy multiple, but diverse, data acquisition and mission requirements.

6.0 Prior Studies and References

NOAA's Aircraft Modernization Study, February 1994 evaluated the long-range trends in NOAA activities requiring aircraft support through FY15. The committee that produced the study was composed of personnel from all line offices, Office of the Administrator, and NOAA Marine and Aviation Operations' (NMAO) Aircraft Operations Center (AOC). The group attempted to project NOAA's aircraft requirements by research category and recommended program planning levels for aircraft modernization. In addition, the instrumentation capability, technology development, composition of the NOAA fleet, and aircrew training requirements were assessed and recommendations for future actions provided. The study also addressed NOAA's use of partnerships and contract opportunities to meet airborne data needs. The study has provided direction to NMAO over the past nine years. NMAO will continue to use portions of the published study to address existing and potential issues.

NOAA Light Aircraft Operations: An Independent Internal Assessment, February 2000 was prepared for NOAA by Mitretek Systems to be used as a quality improvement tool. The report described the current NOAA light aircraft operations as interpreted by the independent observers, provided a cost-benefit analysis of NOAA operations (both in-house and contract), and suggested recommendations for improvement. This document has an extensive bibliography that has been an excellent research tool.

How Will NOAA's Heavy Aircraft Adapt to Programmatic and Technological Changes in the Next 5-10 Years? January 2001 presents the proceedings from the NOAA Heavy Aircraft Conference sponsored by NMAO on July 11, 2000, in Boulder, Colorado. Representatives from NOAA's Office of Oceanic and Atmospheric Research (OAR), National Weather Service (NWS), and National Environmental Satellite, Data and Information Service (NESDIS) met with NMAO personnel to address NOAA's future heavy aircraft needs. The attending members of the NOAA research and operational communities examined the future requirements, summarized the current aircraft situation and future prospects, and formulated recommendations for fleet and instrumentation modernization.
The report can be accessed at: http://www.omao.noaa.gov/fleet.html

NOAA Light Aircraft Forum Session Results, November 15-16, 2001 provides an outline of issues that NOAA light aircraft users discussed during a workshop sponsored by NMAO. The workshop was focused on gathering the inputs of NOAA light aircraft users and service providers on new light aircraft opportunities in NOAA, desirable capabilities sought by line offices, changes in technology and resulting impacts on future requirements, NMAO performance measures, and the expectations that NMAO had for light aircraft users.
The report can be accessed at: http://www.omao.noaa.gov/fleet.html

The Federal Plan for Meteorological Services and Supporting Research, Fiscal Year 2002 is a plan prepared by the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) that articulates the provision of meteorological services and supporting research by agencies of the federal government. The plan describes the role of NOAA aviation assets and researchers in government-wide climate and weather services as of June 2001. The report can be accessed at: http://www.ofcm.gov/fp-fy02/pdf/3-exec_sum.pdf

National Hurricane Operations Plan (NHOP) FY02 presents in section 5.4 the current Tropical Prediction Center requirements for aircraft support. Each year an NHOP is produced to outline the capabilities and responsibilities of an interdepartmental team of government agencies that includes the Department of Transportation and Department of Defense, as well as NOAA, during hurricane season.

NOAA Air Resources Laboratory Airborne (ARL) Research Requirements Workshop was held in Silver Spring, Maryland, on October 8-9, 2002. Representatives from ARL, NMAO, and AOC were in attendance. Topics included ARL contributions to airborne scientific research in the past decade; identification of impacts of the loss of the Long-EZ and its instrumentation; identification of remaining capabilities after the loss of the Long-EZ; expectations of ARL future contributions to airborne scientific research; identification of the immediate needs of ARL to keep existing programs functional; development of a plan to coordinate an ARL airborne research program in future years; and preparation of milestones and a time line for establishment of an airborne research plan.
Workshop proceedings can be accessed at: http://arlaircraft.noaa.inel.gov/

Preliminary requirements study detailing the potential use of aircraft to support the Hawaiian Islands Humpback Whale National Marine Sanctuary and the Northwest Hawaiian Islands Coral Reef Ecological Reserve (FY02) studies the expanded use of aircraft to further the management objectives of the Hawaiian Islands Humpback Whale National Marine Sanctuary and the Northwest Hawaiian Islands Coral Reef Ecosystem Reserve. It also takes the needs of potential partners and other NOAA National Ocean Service (NOS) and NOAA Hawaii-based programs into consideration. The National Marine Sanctuary Program (NMSP) is evaluating and expanding its internal operational capabilities. The NMSP is undertaking a comprehensive analysis of how its operations can be made more effective and efficient by enhancing the use of aircraft within sanctuaries.

Aircraft Needs and Opportunities for Use Within the National Marine Sanctuary Program (FY02) illuminates the needs and requirements for aircraft use in the mainland National Marine Sanctuaries and identifies areas where collaborations within and outside the NMSP and NOAA can be developed to meet these needs. The NMSP is undertaking a comprehensive analysis of how its operations can be made more effective and efficient by enhancing the use of aircraft within sanctuaries. This report reviews the missions, logistical issues, costs, potential partners, and benefits of enhanced aircraft use in the mainland National Marine Sanctuaries.

7.0 Summary of Recommendations

NOAA's in-house flight-hour requirements far exceed the existing resources in both aircraft services line item funding and scheduling availability. Some of NOAA's aircraft requirements cannot be met with outsourcing due to the extensive modifications required on the aircraft. NOAA must operate and maintain a sufficient number of in-house aircraft to retain federal expertise, establish standards in core missions, and meet mission requirements that cannot otherwise be met in the private sector.

To support the line office requirements for in-house flight hours and increased data-collection capabilities, NOAA has evaluated the current fleet of research aircraft and instrumentation, and has begun to change and upgrade the mix and capabilities of platforms.

Actions underway to maintain and increase the capabilities of NOAA aircraft:

- Instrumentation and airframe upgrades to the NOAA G-IV ($8.4M in FY03) and ($4.6M in FY04) are being made to increase data-collection capabilities. These include reconnaissance in addition to surveillance capabilities for hurricane research.

- Bell 212 Helicopter N60RF was disposed of in FY02 due to underutilization. Disposal of the helicopter netted $0.945M that can be used towards the purchase of a DHC-6 Twin Otter . This will increase the number of NOAA Twin Otters to three in support of NOAA programs. The Twin Otter is estimated at $1.9M. Discussions are currently underway to identify the additional funding necessary to bring the third Twin Otter online.

- AC-690 Turbo Commander N53RF will be replaced using $1.55M approved in the FY04 budget. This aircraft supports the Snow Survey Program of NOAA's National Weather Service (NWS).

- NOAA's Office of Oceanic and Atmospheric Research (OAR) requires a light airplane instrumented to support climate studies and air chemistry research. The acquisition of a Velocity airplane is currently under consideration; it would accommodate expanding atmospheric measurement capabilities while retaining the characteristics of an operationally simple airplane. The Velocity is estimated to cost $0.3M to purchase and modify for instrumentation.

- FY04 initiatives submitted for aircraft and instrumentation upgrades are outlined in Chapter 5 (Table 5.0) of this report.

Immediate action items to maintain or increase capabilities of NOAA aircraft:

- A P-3 aircraft already used by the Navy for scientific research is immediately available and NOAA recommends taking possession of it in FY03. This additional P-3 would fill a void in availability to the NOAA research community during hurricane season when both current P-3s are reserved. Two FY05 initiatives have been submitted to make this additional aircraft operational for NOAA: $6.5M PAC for SDLM and overhaul/modification and $1.9M ORF for operations and maintenance.

- Disposing of two current NOAA helicopters (Bell 212 N61RF and MD-500 N59RF) and replacing them with one light twin-engine helicopter capable of working off the NOAA Ship DAVID STARR

JORDAN (and a helicopter-capable replacement platform) is recommended. Two FY05 initiatives have been submitted -- one for $6M PAC to buy and modify the helicopter, and one for $3M PAC (in the INDOMITABLE MRP ship initiative) to construct a helicopter deck and prepare the replacement ship for helicopter operations. INDOMITABLE is scheduled to replace NOAA Ship McARTHUR, and will be the new helicopter-capable ship for fisheries surveys.

- NOAA recommends disposing of both LA-27 Lake amphibian aircraft (N65RF in FY03, and N64RF in FY04). The funds from the first aircraft would be applied toward acquisition of a small environmental research aircraft to replace the Long-EZ lost in an accident in FY02. The disposal of each Lake aircraft is expected to net approximately $100K; the purchase price of a Velocity, which is being considered to replace the Long-EZ, is approximately $250K.

- NOAA atmospheric research scientists are exploring the concept of a new long-term global observing system to provide detailed profiles of the Earth's atmosphere and oceans using unmanned aerial vehicles (UAVs) in a large range of flight profiles to collect data around the clock. A three- to five-year proof of concept mission is being developed beginning with procurement in FY05 of the Global Hawk UAV.

- FY05 initiatives submitted for aircraft and instrumentation upgrades are outlined in Chapter 5 (Table 5.1) of this report.

Future recommendations for enhancements to the current fleet as well as changes to the mix of aircraft include:

- The NOAA Citation II (N52RF) is approaching the end of its useful life and is recommended for replacement in FY06 by an enhanced version of the jet. Given existing and forecast mission requirements, a Citation Sovereign should be evaluated as a replacement for the Citation II. The projected replacement cost is $20M to purchase the aircraft and modify it to conduct NOAA remote-sensing and photogrammetric missions.

- NWS and OAR have indicated that an additional high-altitude jet aircraft would improve NOAA's 24-hour, high-altitude hurricane operations and allow for greater flexibility to support other NOAA climate projects during the hurricane season. If the procurement of an equivalent high-altitude aircraft were initiated in 2006, the aircraft would be mission-ready by late FY08. Acquisition and modification cost is estimated at $90M.

- NOAA's Shrike Commanders (N47RF and N51RF) are recommended for phased replacement in FY10 and FY11, respectively. An estimated $5M will be required to replace N47RF, and $5.1M to replace N51RF.

- NOAA's Twin Otter aircraft (N48RF, N57RF, and the aircraft not yet identified NXXRF) are recommended for wing replacement in FY10-FY12 to extend their serviceable life to at least FY20.

- A detailed study needs to be finished no later than FY10 to determine the best course of action to either continue to maintain or replace the capabilities of NOAA's P-3 fleet. These aircraft are no longer in production, and NOAA is closely monitoring the Navy's plans for extending the service life of their fleet of P-3s. Due to the enormous differential in fleet size between NOAA and the Navy, NOAA should piggyback on the Navy's plans for refurbishment or replacement of their fleet of P-3s; this will save NOAA considerable amounts of money.

Appropriations:

The incremental funding above the FY04 base needed to meet the recommended aircraft platform and instrumentation upgrades and replacements outlined in this report is $140.5M in PAC funds and an $8.1M increase in ORF funds. This will support NOAA's program requirements over the next 10 years.

Personnel:

FTE requirements above the current levels will be required to staff the additional aircraft outlined in this plan. An additional 33 FTEs will be needed at the Aircraft Operations Center to crew and support the recommended additions to the fleet.

Facilities:

Consideration and planning must be given to the increased facilities requirements to house the additional aircraft and FTEs. The current host-tenant support between the Air Force Air Mobility Command and the Department of Commerce for AOC's hangar and office space at MacDill AFB expires in April 2003. The Air Force may ask AOC to move out of the current hangar and possibly build one somewhere else on the base. AOC is initiating a market analysis to determine the funding that would need to be allocated to either support this effort or move the entire operation to another location.

Attachment 1

UNITED STATES DEPARTMENT OF COMMERCE
The Deputy Under Secretary for Oceans and Atmosphere
Washington, D.C. 20230

JUL 30 2002

MEMORANDUM FOR: Rear Admiral Evelyn J. Fields, NOAA
Director, Office of Marine and Aviation Operations

FROM: Scott B. Gudes

SUBJECT: Request for Report of NOAA's Platform Requirements

The Office of Marine and Aviation Operations (OMAO) is requested to conduct a thorough, up-to-date analysis of the National Oceanic and Atmospheric Administration's (NOAA) platform requirements as well as how NOAA will fulfill those requirements during the next 10 years.

OMAO is requested to perform this task for all parts of NOAA, with input from and coordination with the Line Offices. This comprehensive report for vessels should be delivered to Vice Admiral Lautenbacher, U.S. Navy (Ret.), within three months of the date of this memorandum. In the report, please focus on the ship needs of the following missions: fisheries surveys and science, hydrographic surveys, blue water oceanography and climate research, coastal oceanography, ocean exploration, and homeland security (if appropriate). As a term of reference, a common definition of days-at-sea needs to be employed. The report should also develop a rigorous breakdown of days-at-sea required by the operational components listed above and project those days-at-sea requirements into the future. The report should project the expected serviceable life of our current fleet platforms. It is important that this report document and forecast requirements for NOAA's use of the University-National Oceanographic Laboratory System (UNOLS) and contract ships required to perform our mission as well. As a further aspect, the report should also address human resource requirements and technology improvements.

This report should take full account and reference as necessary past studies of the NOAA fleet, including Rear Admiral Craig Dorman's, U.S. Navy (Ret.) report in 1998, the 1993 NOAA Fleet Replacement Plan, and other relevant sources. In response to these past studies, your report should encompass findings on how NOAA can best meet its data collection needs while working with a mix of other federal, academic, and private sector resources. Ideas for new ways of doing business should be included in the report. For example, Captain David MacFarland of the National Ocean Service, Office of Coast Survey, has fundamentally changed the model of how hydrographic surveys are conducted, including using time charter vessels. I would particularly like to see his involvement in this report, as I expect innovative suggestions to be put forward regarding this plan. Please keep in mind that the NOAA plan will most likely become a key part of a national oceanographic fleet replacement plan.

I would also like a similar analysis done on NOAA's aircraft requirements. That plan will be due within six months of the date of this memorandum.

cc: NOAA Executive Council Members
NOAA Executive Panel Members

Appendix A
NOAA Aircraft Summaries

Gulfstream IV-SP (N49RF)

Supports: Weather and Water Impacts, and Climate Variability

The Gulfstream IV-SP (G-IV) is a high altitude, high speed, twin turbofan jet aircraft acquired by NOAA in 1996. The G-IV supports the National Hurricane Center synoptic surveillance mission and winter storm reconnaissance. This aircraft collects, processes, and transmits vertical atmospheric soundings in various weather conditions, including the environment of a hurricane. The principle tool used for this task is the GPS dropwindsonde. The dropwindsonde is released from the G-IV measuring and transmitting back to the aircraft the pressure, temperature, humidity, and GPS Doppler frequency shifts as it descends to earth. The Doppler shifts are used to compute the horizontal and vertical wind components which are then transmitted to the National Centers for Environmental Prediction and the National Hurricane Center for inclusion into the global and hurricane model runs.

Lockheed WP-3D Orion (N42RF & N43RF)

Supports: Weather and Water Impacts, and Climate Variability

NOAA operates two of the world's premier research aircraft, the WP-3D Orions. NOAA's WP-3D's participate in a wide variety of national and international meteorological, oceanographic and environmental research programs in addition to their use in hurricane research and reconnaissance. These versatile turboprop aircraft are equipped with an unprecedented variety of scientific instrumentation, radars and recording systems for both in-situ and remote sensing measurements of the atmosphere, the earth and its environment. Obtained as new aircraft from the Lockheed production line in the mid-70's, these robust and well maintained aircraft have led NOAA's continuing effort to monitor and study hurricanes and other severe storms, the quality of the atmosphere, the state of the ocean and its fish population, and climate trends. With its world-wide operating capability, they have participated in numerous research experiments from the Indian Ocean, Australia and the Solomon Islands to Ireland, the North Sea and the Alps. On a national scope they have operated from the Arctic Ocean and Alaska through most regions of the U.S. and into the Caribbean. Hurricane and tropical storm research has taken place in the Atlantic, Caribbean, Gulf of Mexico and the Eastern Pacific. Without a major service life extension program, estimated useful lifetime for these two research platforms is another 10 to 15 years.

Cessna CE-500 Citation II (N52RF)

Supports: Commerce/Transportation, Coastal/Ecosystem & Homeland Security

The Cessna Citation is a highly modified twin-engine jet aircraft. Standard configuration allows for mission equipment, two pilots, and one or two equipment operators. The Citation's primary mission is to support the National Geodetic Survey (NGS) Remote Sensing Division in its assessment of new remote sensing technologies to support Nautical and Aeronautical Charting. NOAA's Citation has a unique side-by-side camera/sensor modification allowing two different film emulsions or sensor inputs to be exposed simultaneously. Additionally, two independent survey quality GPS antennas and precision GPS receivers provide centimeter-level horizontal accuracy with the use of a differential GPS site. The primary focus of new technology assessment in the Citation is directed toward the requirement for accurate shoreline, aeronautical obstruction, and digital elevation modeling surveys. Shoreline surveys are critical to the safety of ship navigation, and result in updates to nautical charts and electronic databases. Aeronautical obstruction surveys are critical to the safety of flight and result in changes to the FAA instrument approach procedures. Additionally, the Citation has been flown for storm profiling, post flood photography, environmental photography, coral reef mapping, and post-September 11 World Trade Center disaster surveys.

DeHavilland DHC-6-300 Twin Otters (N48RF & N57RF)

Supports: Coastal/Ecosystem, Climate Variability, Commerce/Transportation

The DeHavilland Twin Otter is a high wing, twin turbo-prop airplane which is extremely versatile, highly maneuverable, and can be flown at low airspeeds. NOAA currently operates two Twin Otters, and due to the overwhelming demand for this platform, is in the process of procuring a third. A standard flight crew consists of two pilots and up to eight scientists. The combination of its rugged "bush plane" construction, turbine reliability, and high-wing design, make the Twin Otter perfectly suited for a wide range of scientific missions. Due to the un-pressurized design, the Twin Otter can be modified to suit individual projects relatively quickly and inexpensively. In support of NOAA or NOAA-related missions, the Twin Otter conducts low-level slow speed aerial surveys of marine mammals, aerial video surveys of coastal erosion, a wide range of LIDAR missions, airborne topographical mapping, multi-spectral scanning projects, atmospheric air chemistry sampling, and atmospheric eddy flux and concentration gradient assessments.

Gulfstream AC-690Turbo Commander (N53RF)

Supports: Weather and Water Impacts and Commerce/Transportation

The Gulfstream Turbo Commander (AC-690) is a stable high-winged twin, pressurized turboprop aircraft that is suitable for a variety of missions. Standard configuration allows for the mission equipment, two pilots, and one photographer. However, with all seats installed, four scientists/technicians can be accommodated in the cabin. The Turbo Commander is scheduled for service life extension or replacement in FY 2004. NOAA's AC-690 Turbo Commander is utilized by the NWS National Operational Hydrologic Remote Sensing Division to conduct airborne surveys in support of operational hydrology programs. Equipment onboard the aircraft measures natural terrestrial gamma radiation which is used to determine snow water equivalent and soil moisture content of a given area. The Nation's water resource managers use this information to help reduce the loss of life and property due to flooding and maximize the use of the Nation's limited water supply. Historically, the NGS conducted aeronautical surveys requiring collection of stereo photographic and remotely sensed data. These surveys facilitate coastal mapping, airport obstruction charting, photo bathymetry, photo geodesy, boundary determination, and coastal wetlands mapping. Depending on the scale of imagery required, missions were flown at altitudes of 1000 to 24,000 feet above ground level using kinematic GPS survey techniques. Through post-processing methods, such as photo-interpretation and photogrammetric measurement, the NGS used the data to develop NOAA charting products.

Rockwell AC-500S Aero Commander (N47RF & N51RF)

Supports: Weather and Water Impacts, Coastal/Ecosystem, Commerce/Transportation

NOAA operates two Rockwell Aero Commanders (AC-500S). This type of aircraft is a versatile and stable, high-winged, twin piston-engine aircraft that is suitable for a variety of missions. N51RF primarily serves the National Operational Hydrologic Remote Sensing Center. This National Weather Service program conducts airborne surveys to support various hydrology programs. Equipment onboard the aircraft measures terrestrial gamma radiation. Since this radiation is uniformly attenuated by water, these measurements can be used to determine the snow pack and soil moisture content of a given area. Measuring this "snow-water equivalent" in hundreds of locations throughout North America provides water resource managers valuable information to forecast snow runoff. These forecasts, in turn, help reduce losses due to flooding and allow optimal usage of water supplies.

Aero Commander N47RF is utilized for a variety of different missions. This aircraft has been modified to accept a high resolution aerial camera system. In this configuration, the camera is used to verify and measure the location and heights of obstructions to air navigation. This system can also be utilized for hurricane and flood damage assessments. The aircraft can also be outfitted with a hyperspectral scanner and a variety of other remote sensing equipment. Historically, the National Ocean Service (NOS) conducted aerial surveys for visual verification of aeronautical charts and high-resolution aerial photography with Aero Commander N47RF. The responsibility for this mission has been shifted to the Federal Aviation Administration (FAA). Additionally, the aircraft has been used in biological investigations, such as algal bloom measurements and marine mammal and sea turtle population assessments, and post-hurricane damage assessment photography.

Bell 212 Helicopter (N61RF)

Supports: Coastal/Ecosystem, Homeland Security, Commerce/Transportation

The Bell 212 helicopter is extremely versatile in mission profile and operational parameters. It can be flown from a hover through speeds up to 120 knots. The standard configurations can allow for mission equipment plus equipment operators or with the scientific equipment removed, seating for up to 13 scientists/technicians not including the pilot(s). The Bell 212 is transportable on cargo airplanes for relocation to distant work-sites and international operations. NOAA's Bell 212 helicopter has been used for a variety of scientific missions including Florida Everglades aerial surveys, MacDill AFB security checks, nautical charting via laser hydrography, base camp relocations in the arctic, polar bear tracking/tagging, establishing geodetic bench-marks in remote locations, filming waterspouts, surveying coastlines, assessing oil spill damage, low-level survey work, and providing logistical support for environmental studies.

McDonnell Douglas MD500 Helicopter (N59RF)

Supports: Coastal/Ecosystem, Homeland Security

The MD500 helicopter is extremely versatile in mission profile and operational parameters. It can be flown at speeds ranging from a hover up to 150 knots. Standard configuration allows for mission equipment, an equipment operator and one pilot. However, with the scientific equipment removed, seating for up to 3 scientists/technicians may be installed. The MD500 is transportable on a cargo airplane for relocation to distant work-sites and international operations. NOAA's MD500 helicopter has been used to assess oil spill damage, survey coastal erosion, conduct security checks of MacDill Air Force Base, survey marine mammals via vertical aerial photography, and is the only airframe currently capable of operating off of the NOAA ship DAVID STARR JORDAN.

Lake LA-27 Renegade Seawolf (N64RF & N65RF)

Supports: Coastal/Ecosystem

The Lake Renegade Seawolf (LA-27) is a cost effective, dependable platform for near shore low-level surveys. NOAA operates two of these single turbo-charged piston engine amphibious aircraft. A standard crew consists of one pilot and up to three scientists. One Lake aircraft is stationed on the West Coast to support National Marine Sanctuary research and enforcement efforts. The other LA-27 is positioned at MacDill AFB, Tampa, FL. to support scientific programs and pilot proficiency training. In the past, the Lake aircraft have been utilized for low level biological surveys (ex. red drum, sea turtles, and marine mammals).

Appendix B

NOAA G-IV System Upgrades FY03- FY04

White Paper - NOAA G-IV System Upgrades

2 December 2002 Alan S. Goldstein

Acquisition Sensitive Information - For intra-governmental use only

Background

When first purchased, the NOAA G-IV was expected to perform hurricane reconnaissance and meteorological research in addition to the hurricane surveillance mission. Initial funding only provided for the infrastructure and instrumentation required for the surveillance mission. Although NOAA's Aircraft Operations Center (AOC) has made some small modifications (notably window blanks for mounting instruments), the major enhancements originally envisioned were beyond AOC's resources. In 1994, a working group identified a suite of instrumentation to measure some parameters normally associated with the hurricane reconnaissance mission performed by low level turboprop aircraft. The working group's report [1] was the basis for a funding initiative, with $8.4M to be provided in Fiscal Year 2003 (FY03) and an additional $4.6M in FY04.

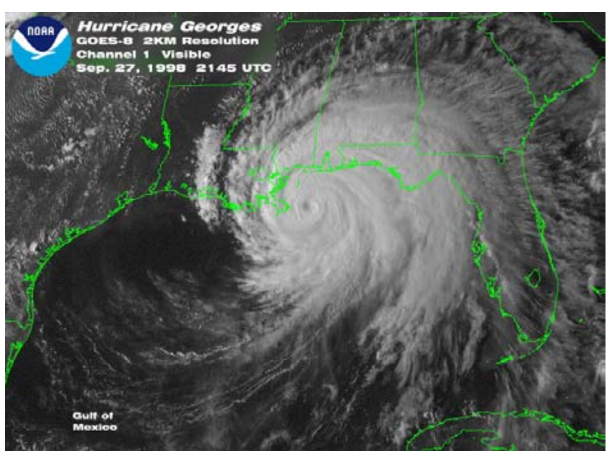
A Change in Focus

The original working group met before the aircraft was selected and purchased. Since that initial meeting, there have been many developments and findings which will necessitate changes to the priorities and goals of the G-IV upgrade program. Among these developments:

- AOC has had time to explore the operating characteristics and envelope of the G-IV. We had gained considerable experience near the central core of a variety of storms. Based on that experience, it is likely that the G-IV will be unable to safely penetrate the central core of some hurricanes, or be unable to navigate through the convection in some quadrants of a particular storm. This potential limitation has been addressed by NWS [2], relaxing the central core penetration requirement.
- It has become apparent over time that despite the advances in remote sensing, a high altitude platform is not suitable for making all of the measurements required by the classic reconnaissance mission. An example is minimum surface pressure, which is usually measured by a combination

of low level dropwindsondes and extrapolated surface pressure. From G-IV altitudes, it is doubtful that even a spread of sondes would provide a hit on the pressure center, as sondes tend to advect away from the center as they fall. The G-IV flies too high for useful extrapolation.

- With the focus shifting away from central core penetration and classic reconnaissance, the remaining priority from the 1994 working group is to provide 'detailed information' for 'input into numerical models'. NWS is developing the next generation of forecast software, the Weather Research and Forecasting (WRF) computer model. WRF will include a module that will address hurricane track and intensity forecasting. A meeting was held last May (2002) to determine and prioritize measurement parameters most useful to the WRF model [3]. This prioritized list is the nucleus of a revised instrumentation suite and the infrastructure to support it.
- A set of instrument pods were purchased with some of the initial G-IV funding. The pods were supposed to be the first step in a mounting system for a down-looking radar. The funds were not sufficient for testing and certifying the pods. During the engineering analysis, it was identified that the pods will need to be anti-iced. The conventional method of anti-icing, namely heater blankets on the leading surfaces, would require significantly more electrical power than is currently available from the engine generators. A preliminary study showed that increasing generator capacity would cost about $10M, thus making it cost prohibitive under the current funding initiative. Other (negative) aspects of the pods are the anticipated loss of performance due to the drag penalty, and the integrity of the pod construction. Gulfstream (the G-IV manufacturer) has done a preliminary evaluation of the pod construction and aerodynamic impact. That report highlights many concerns and potential problems, with the corollary that it will take extensive analysis, testing, and (probably) redesign to address those concerns. The pod development, along with AOC's other experience at modifying and instrumenting the G-IV highlights the difficulties that can be expected in the future. Many issues have been related to airflow disturbance or anti-icing of instruments mounted on the side of the aircraft, in front of the static ports and the engines.



<u>hTenets and Guidelines</u>

As we go through the process of identifying infrastructure and instrumentation, there are several basic premises that should help focus the discussion:

- Even with technological innovations, low level turboprop aircraft will be required for the reconnaissance mission for the foreseeable future. As an integral part of the measurement system, their current capabilities will be available. It follows that unless the G-IV can provide some enhancement or value-added to a measurement that is normally performed by the turboprops, there is little reason to provide that capability on the G-IV. As a separate exercise, NOAA may wish to address instrumentation changes or additions for the turboprop aircraft to better support the WRF model.
- Unless future studies (which will not be completed within the time frame of this instrumentation effort) prove differently, the G-IV will not be able to safely penetrate the central core of every Tropical Cyclone (TC). This should not totally discount the G-IV's capability to approach and sometimes penetrate the central core, if that would provide some value to forecasters or the WRF model (e.g. measuring the high altitude temperature anomaly structure in the core). Flight pattern capabilities may help determine instrument priorities, as instruments which require core penetration may have less usefulness than systems that can provide data without core penetration.
- Most of the measurements identified in the WRF workshop are for model verification, the lone exception being three dimensional wind fields. Verification measurements, while important, should be treated as a transient requirement. Model verification efforts fall more into a research category, with specialized equipment and flight patterns required on a short term (in this case, probably 2-5 years) basis. Permanent modifications to the aircraft should be limited to generic provisions to allow a variety of instrumentation to support model verification. All platforms should be considered in determining how specific measurement methods and instruments will be deployed, as the P-3's already have a very capable and flexible infrastructure for developmental instruments.
- As a follow-on comment, the G-IV and P-3's have very different capabilities and flight regimes. For each measurement and instrument required for WRF validation, the choice of platform should be based on instrument characteristics and flight profile capabilities. In some ways, the G-IV has many characteristics of a satellite, albeit at a lower altitude and with more available power and weight capacity. This can be a positive (test bed for instruments destined for satellite mount) or a negative (poor resolution of low level detail due to beam spread, etc.), but should be a consideration in selecting a platform.
- One of the most important considerations is that the G-IV already has a mission, providing critical synoptic data to forecast models and NHC personnel. Although the Air Force's C-130J aircraft have demonstrated the capability to accomplish at least part of that mission, the G-IV's altitude, range and operating cost make the jet the platform of choice for most tasking. Down the road, if the C-130J's become certified for inner core work and the C-130H models are decommissioned, the Air Force may not have enough assets to respond to synoptic surveillance tasking. In the short term, support from the C-130J's may allow the G-IV to do some validation and developmental work. In the long term, barring the purchase of another high altitude jet, the

permanent instrumentation and flight patterns to support the WRF model should be designed to co-exist with the surveillance mission.

Major Components

The upgrade effort can be divided into three major subsections. They are: Upgrades to Infrastructure, Provisions for New Instrumentation, and Instrumentation. In the original plan, the first $8.4M was earmarked for infrastructure and provisions for new instrumentation, with the follow-on $4.6M in FY04 for new instrumentation. Although the scope and direction of the upgrade effort has changed, the use of funds still falls roughly within the original plan's division.

Upgrades to Infrastructure

This includes modifications and improvements to existing aircraft and scientific systems. The list is well defined, as we have noted specific deficiencies during the operation of N49RF over the last 6 years. The following have been proposed:

1) Upgrade to Satcom - Replace current Honeywell MCS-3000 system with a high speed (64-128K baud) satellite communication system, preferably supporting ISDN connectivity and MPDS Packet data.

2) Replacement of the Global-Wulfsberg Passenger Communications System - Replace with a digital communications management system that will simplify telephone and messaging operations on the G-IV.
3) Replace current digital networks - Replace daisy-chained 10Base-2 and IRIG-B networks with 1000Base-T and/or Fiber star topology networks. Provide at least three network connections (Data, Display, and User) at each station, with central switch unit for each network.

4) Replace existing data collection system with new system that has better stability, sampling, collection options and display capability.

5) Enhance nose radar capability for wind shear detection and multiscan cloud top display. This may be accomplished through the original manufacturer, who is providing this capability on their X-band radar systems, or may be part of the nose radar data system (see below).

Desired Measurements and New Instrumentation

Before discussing modifications to provide for new instrumentation, it is best to examine the measurements to be taken and the proposed instruments to do the job. Much of this is based on the May 2002 WRF Workshop.

1. Winds - Three dimensional, everywhere, all the time - As has been discussed, the G-IV is not the best platform for surface wind measurements. The P-3 tail Doppler radar is much better suited to that task, augmented by C-band scatterometry and a Stepped Frequency Microwave Radiometer (SFMR). For the Air Force C-130's, either tapping into the nose radar or some type of upper pod radar may be the best option, with a wing pylon mounted Ku-Scatterometer and SFMR for detailed surface wind observations. Due to low operating altitudes, the turboprop aircraft are poor choices for measuring winds in the upper reaches of the storm, and would have trouble measuring clear air winds because they spend a lot of time in heavy convection. Therefore, for the G-IV:
    a. Modified nose radar to record and composite reflectivity and velocity measurements, with automatic tilt management for creating volume scans. No aircraft structural modifications required. Several possibilities exist for implementing the modification, probably requiring work by the radar manufacturer to access signals and data within the radar Receiver/Transmitter and work by another contractor or agency to collect and record data, derive computed parameters, composite data into volume space and select subsets for display and transmission. Tapping into digital I and Q data within the radar should minimize certification issues.
    b. If nose radar modification is not feasible or does not provide the desired coverage or scan pattern, then some other type of scanning Doppler radar will be required. Focusing on outflow winds at and near the G-IV's altitude, this radar may take the form of a horizontally scanning unit mounted in a belly pod. Until it is determined that this alternative is required, the plan does not specifically address this radar development, but provisions for these mounting options are being included to support other instruments. One variation on the theme is to initially mount an X-band system in a belly pod, and after some period of comparison operation, migrate it to the nose radome to replace the existing system.
    c. For clear air wind measurements, a Scanning Doppler Lidar system with fore/aft look angles and variable tilt pattern (similar to NASA MACAWS system) is the best existing technique. The simplest installation would use one or two (to look out both sides of the aircraft) of the existing window blanks. If the Lidar can be designed so that the optics are flush with the fuselage, anti-icing issues may be avoided. Although both NASA and NOAA/ETL have some experience in fabricating Doppler Lidar's, the requirements for an operational, compact, (preferably) eye-safe system will require a significant development effort.
    d. As previously stated, surface wind measurements in and near the core are better handled by other platforms. Measurements in the far periphery of the storm by the G-IV may be provided by one or more candidate instruments. The easiest to incorporate would be the NASA GORE GPS Backscatter system. Although less deterministic than other instruments, the installation only requires a down-looking GPS antenna. Currently, this system is still in the developmental stage, and no useable data sets have been produced. There are two other instruments with proven capabilities, albeit on the lower altitude P-3's. One is the aforementioned SFMR, which may require significant modification before it will work on the G-IV. It could be mounted in a belly pod, a modified tail cone, or on a wing hard point. The other is a Scatterometer mounted in a belly pod. A unit working in the X or Ku frequency band would provide surface wind readings in areas away from

heavy convection. As the G-IV surveillance pattern is mostly away from the storm center, an X- or Ku-scatterometer should work with acceptable attenuation, providing data in the periphery which is not normally covered by the turboprop aircraft. Due to the various technical and physical reasons mentioned, these three instruments are lower on the priority list.

2. Temperature - Vertical Structure - Again, besides dropwindsondes and in-situ sampling, the best instrument identified is:
   a. NASA Microwave Temperature Profiler (MTP) - Very compact unit that may be mountable on a window blank or in the wingtip light assembly. Scanning sensor assembly is 23L x 17D x 13H cm (9 x 6.7 x 5.1 in) and requires a zenith-forward-nadir half-circle scanning pattern. There are several mounting possibilities, each with tradeoffs. MTP system requires a synoptic scale atmospheric model as a template; this may be dynamically configurable using real time dropwindsonde data. Significant post-flight data processing is required to provide best accuracy for WRF verification, but real time output may be good enough for other applications.

3. Ocean Temperature - Sea surface temperatures are best measured by low level aircraft using infrared radiometry, possibly augmented by microwave radiometer. For the G-IV, the best contribution would be to measure temperature-depth profiles in regions that are not covered by the turboprop aircraft. This would require:
   a. Airborne Expendable Bathythermograph (AXBT) in a GPS dropwindsonde form factor. Ideally, this instrument would provide a digital data stream to the aircraft with telemetry and bit format compatible with the existing NCAR dropwindsonde system. This would allow implementation without any modification to the aircraft, and would allow use on any AVAPS equipped platform. Bit stream format and container size may allow additional instrumentation in the package (some subset of GPS dropwindsonde instrumentation or one dimensional accelerometer which the sonde can integrate to surface wave height - see item #6).

4. Moisture - Vertical Structure - Besides the existing resources (dropsondes and in-situ), the best support for this measurement is:
   a. Differential Absorption Lidar (DIAL) system - Requires at least a down-looking view port (DC-8 style system also requires an up-looking port) and requires a significant optical system. Discussion with DIAL experts will be required to identify variations and tradeoffs. Viewport(s) will be a significant airframe modification; may be able to use real estate currently occupied by down PRT-5 radiometer port, albeit with a much larger hole. May need chin fairing if optical flat window is required.

5. Rain/Microphysics - Rain and melting level (bright band) can be resolved by tilt managed radar. Cloud microphysics measurements over broad areas may be best accomplished with dual polarization radar. This would be difficult to mount on the G-IV, as it would need an entirely new radar system; realistically, the nose system could not be modified for this application. A tail radome equipped P-3 (NOAA or NRL) and/or satellite would be better candidate platforms. What the G-IV could contribute would be in-situ measurements in the upper regions of the storm,

both as a primary measurement and to provide 'ground truth' data for remote sensors. Therefore, for the G-IV:

a. One set of cloud physics probes in the standard PMS canister form factor. The suite of candidate probes should be able to measure particles from aerosol to small solid particles (0.3 - 1600 microns). To cover this range of particle sizes will probably require 2-3 probes. Probes will need modification to operate at the G-IV's high true air speeds. Infrastructure required includes underwing hard points (at least 1 per wing) and two pylon assemblies with two PMS canisters on each pylon.

6. Ocean Waves - As with surface winds, low aircraft are better for measuring wave characteristics. The G-IV's contribution should be based on its extended operating range from the center. In the periphery, fine details of wave structure (typically desired in the core) are less important than a large scale gridded data set. As mentioned above in #3, a one-dimensional accelerometer incorporated into the miniature AXBT would give point readings of wave height. This could be augmented with:

   a. Some variation of Ed Walsh's Scanning Radar Altimeter (SRA). His current version works at 35 GHz, and does not work in heavy precipitation due to the attenuation at that frequency. Options to make it work on the G-IV may include designing at a lower operating frequency, improving the gain and beam pattern (which may need to be done anyway due to the G-IV's altitude), or accepting the SRA's limitations, as the G-IV will not be spending much time looking down into heavy precipitation. The SRA will require a pod or fairing on the underside of the fuselage or hanging from a wing hard point.

7. Ocean Currents - The G-IV is probably not the best platform to do ocean current measurements. Remote sensing techniques have not been developed to the point of identifying a suitable instrument for a high altitude aircraft. If ocean current measurements are a high enough priority (which has not been indicated to date), a miniature Airborne Expendable Current Probe (AXCP) might be developed, similar to the mini-AXBT discussed above.

8. Radiation - No specifics - G-IV could be outfitted with IR (PRT-5) and long wave (pyranometers and pyrgeometers) sensors without much penalty in drag or weight. More specifics would need to be determined. Pyran's and Pyrgeo's might be pod or blister mounted to the fuselage.

The summarized new instrumentation list (in priority order) is:

1. Modified nose radar system
2. Meteorological Radar System (if required)
3. Scanning Doppler Lidar
4. NASA Microwave Temperature Profiler
5. Miniature AXBT with wave height measurement
6. Ku- or X-band Scatterometer
7. Stepped Frequency Microwave Radiometer
8. NASA GORE surface wind system
9. Differential Absorption Lidar system
10. Cloud Physics system
11. Scanning Radar Altimeter

<u>Provisions for New Instrumentation</u>

Having identified a candidate instrumentation suite, the provisions for those instruments can be listed. They are in priority order, and are subject to change based on changes to the proposed instrumentation list. Still, most of the items are designed to be somewhat generic in nature so that they can accommodate a variety of instrumentation, both for WRF model input and other weather research.

1. Modifications to infrastructure for communication, networking and data collection.
2. Under-fuselage pod for meteorological radar, Scatterometer, SFMR, SRA, etc. (lower priority w/o met. radar)
3. Wing Hard Points
4. DIAL Laser Port(s)
5. Pylons for PMS canisters

<u>Summary and Next Steps</u>

This document proposes a new list of prioritized modifications and instrumentation to support the development, verification and on-going data needs of the next generation WRF hurricane computer model. It tries to focus on measurements and instrumentation best suited to the G-IV platform and flight environment. It does not resolve conflicts between the existing surveillance mission and either the upgrade effort or the flight patterns that may be required for WRF measurements.

Although in priority order, the proposed list is all-encompassing and does not account for actual limitations in funding, space and weight. It is almost certain that some items on the list will be dropped due to one or more of these factors. Those decisions can not be made until a critical scientific review of the proposed instrumentation suite is performed, followed by individual engineering reviews of each system. At that point a firm acquisition and installation plan can be generated and approved, followed by implementation of the upgrade effort.

<u>References</u>

[1] Proposal to Modify NOAA's GULFSTREAM IV Jet as Prototype for the Next Generation Manned Hurricane Reconnaissance Platform - 08 February 1999 - Copies available from AOC

[2] Mission Needs Statement for Hurricane Reconnaissance by Jet - Undated - Transmittal by Dr. Naomi Surgi - Attached

[3] Hurricane WRF Workshop Arlington, VA - 29-30 May 2002 - Summary provided by Dr. Frank Marks – Attached

MISSION NEEDS STATEMENT FOR HURRICANE RECONNAISSANCE BY JET

The primary purpose of manned hurricane reconnaissance is to provide detailed information about the storm's size and strength of circulation from the upper troposphere to the ocean surface by remote sensing instrumentation. Another requirement, which is already operational, is the ability to perform the hurricane surveillance mission, gathering vertical profiles of wind, temperature, and humidity within 1,000 km of tropical cyclones by means of dropwindsondes released from the upper troposphere over data-sparse oceanic regions. Although it is not necessary to combine the reconnaissance mission with the surveillance mission, performing both types of missions which may be desirable for a single storm requires the range, endurance and ceiling that can only be achieved by a transport category jet.

The NOAA Gulfstream IV-SP high altitude jet is currently configured for the surveillance mission, but will need further airframe modifications and instrumentation to perform reconnaissance. Funding was provided for the G-IV under Public Law 103-121, which appropriated funds for "the next generation aircraft reconnaissance system," and in a 1995 supplemental appropriation. Senate Appropriations language noted at that time that "**This aircraft was funded to perform hurricane reconnaissance, not merely hurricane surveillance.**"

To accomplish the mission objectives, the G-IV must be equipped with a suite of next generation instrumentation. Performing the reconnaissance mission by jet will involve measurements from an altitude of ~43,000 ft. to take measurements in the core of the storm. Parameters to be measured include the vertical profiles of the horizontal winds (from the surface to the top of the storm), vertical wind profiles (from the surface to the top of the storm), vertical profiles of temperature and humidity, with special emphasis on the surface winds and the rainfall distribution. These data must be made available, in real-time, for input into NCEP's numerical hurricane models and to the National Hurricane Center support operational forecast needs.

This data will provide a three-dimensional description of the storm with information on the size and intensity of the storm. This information is critical to initialize and improve the next generation high-resolution mesoscale models that predict hurricane track and intensity changes. These observations will also improve specification of the strength and size of tropical storms for use in the warning process. These expected improvements will reduce overwarnings and associated costs, and provide more timely and accurate information for preparedness actions. Additionally, this platform will provide a means to develop and test components of the next generation operational reconnaissance system into the next century, that will not only provide much improved forecasts, but potentially will reduce current operating costs significantly.

OBSERVATIONAL G-IV RECCO REQUIREMENTS

The G-IV measurements do **NOT** require the position of center of low-wind circulation nor central surface pressure, which is the traditional central fix for the low-altitude turbo-engine reconnaissance missions. Those missions are already carried out by the AFRES-53 with supplemental flights provided by the NOAA WD-P3's.

The ***desired*** reconnaissance measurements by the G-IV are provided below; however, some of these measurements may not be possible all the time with this aircraft for strong tropical systems. This is wholly left to the judgment call of the G-IV PIC. Many of the missions however, may call for high-altitude missions for weak tropical systems into which the circulation centers are more difficult to define. For these systems, the G-IV might only be tasked to take preliminary storm scale circulation measurements.

DESIRED MEASUREMENTS FROM G-IV RECCO MISSIONS

1. RADIUS-HEIGHT (R-Z) MEAN PROFILES of HORIZONTAL WIND COMPONENTS
   (Mean Vortex, Tangential and Radial Wind)
   Surface to 200 mb Minimum

2. SURFACE (10 m) TOTAL WIND FIELD

3. SURFACE (10 m) RAIN RATES

ENHANCED FORECASTING TECHNIQUES

4. MAPS of ASYMMETRIC HORIZONTAL WIND FIELD
   Surface to 200 mb

5. R-Z PROFILES of VORTEX_SCALE (5-10 km) VERTICAL WIND COMPONENTS Surface to 200 mb

UPGRADING to RECONNAISSANCE INSTRUMENTATION

- REMOTE SENSOR SUITE
  - C-Band Scatterometer (C-SCAT) /
    Vertically Scanning Doppler Radar (VSDR)
  - Step Frequency Microwave Radiometer
  - Joint Data System (C-SCAT/SFMR)

- AIRFRAME MODIFICATIONS REQUIRED

- C-BAND NOSE RADAR IMAGERY
  - Signals to Data System
  - Upgrade HAPS w/ Radar Compositing Software
  - Doppler Processing for Wind Speeds

- UPGRADE DROPSONDE SYSTEM (AVAPS)
  - Increase Number of Channels from 4 to 8
  - Develop Fast-Falling Sonde

- AUTOMATED RECCO MESSAGES, VORTEX REPORTS

PHASED RESEARCH AND DEVELOPMENT EFFORT

UPGRADE CURRENT INSTRUMENTATION IN THE NEAR TERM

Integrate C-Band Nose Radar Data
Add Channels to AVAPS
Transmission of Flight-Level Data

LONGER-TERM INSTRUMENTATION EFFORT

Fly SFMR and C-SCAT/VSDR Prototypes on P-3's
Software Development
Refine Requirements

DECISION POINT (2 Years After Project Go-Ahead)

RECONNAISSANCE INSTRUMENTATION PACKAGE INTEGRATION

Develop and Acquire Operational C-SCAT/VSDR and SFMR
Competitive Procurement of Airframe Modifications
Flight Testing
Transmission of Data Products for NHC

ON-GOING EFFORTS

Development of Data Products for Reconnaissance
Development of Flight Techniques and Mission Profiles

Hurricane WRF Workshop
Arlington, VA 29-30 May 2002

Data Working Group:

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John Derber	NWS/EMC
Bob Maxson	NOAA/AOC
Jim DuGranrut	NOAA/AOC
Alan Goldstein	NOAA/AOC
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John Gaynor	NOAA/USWRP/IPO
Ward Seguin	NOAA/USWRP/IPO
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Peter Black	NOAA/HRD
Nick Shay	UM/RSMAS

Summary of Discussions on Data needs for the Hurricane WRF:

We met to go through Naomi's list of issues to be addressed. The issue was defining the data types, sources, and strategies needed to initialize the hurricane WRF model. Our focus was on a type of targeted observations, in the sense that the storm vortex was the target, needed to best initialize the vortex in the model using the hurricane WRF data assimilation system (DAS) yet to be defined. Below is an outline of those discussions.

Necessary types and resolution of observations to define the hurricane core circulation (in priority order)

A. Wind:
Three-dimensional structure essential for model input
Radial resolution most important – 0.5-1.0 km
Height resolution next most important – high resolution (100 m) in ABL,outflow, and to resolve eyewall slope
Azimuthal resolution – at least wave #2

B. Moisture:
Vertical structure essential for validation.
Critical in environment surrounding core. Model generated moisture will dominate the core.
Height resolution critical – high resolution (100 m) in ABL.
Azimuthal resolution next most important – at least wave#1
Radial resolution – 10-20 km

C. Temperature profile:
Vertical structure essential for validation.
Mean vertical profile, plus variation in radius and wave#1 in azimuth would be extremely useful for validation

Height resolution critical – high resolution (100 m) in ABL and near tropopause.
Radial resolution next most important – 10-20 km
Azimuthal resolution – at least wave#1

D. Ocean temperature and heat content:
Essential for verification
Radial and azimuthal resolution - critical between center and 200-250 km (24 h) ahead of storm
Vertical resolution – mean values in the mixed layer critical – need to resolve mixed layer (10-20 m)

E. Microphysics/rain/reflectivity:
Essential for verification
Vertical structure critical – resolution to resolve the melting level (250 m)
Radial resolution next critical – resolve the eyewall (1 km)
Azimuthal resolution least critical – wave #2

F. Ocean waves:
Essential for verification
Azimuthal structure critical – resolve asymmetry in wave height and length wave# 2
Radial structure next critical – resolve radius of 8' and 12' seas - 20-50 km

G. Ocean currents:
Essential for verification

H. Radiation:
Essential for verification

II. Candidate instrumentation suites for observations to define the hurricane core circulation (in priority order)

A. Wind:
Airborne and ground-based Doppler radars (limitation: winds only where it is raining, and poor vertical coverage near surface because of ground clutter)
Satellite scatterometers/SAR and cloud drift winds (limitation: scatterometer/SAR
only surface level; cloud drift winds - coarse and uncertain resolution in vertical)
Microwave radiometric retrieval (AMSU) (limitation: model assumptions for retrieval)
Aircraft in-situ (limitation: one level)
Dropsondes (limitation: spatial resolution)
Doppler LIDAR (limitation: winds where it is not cloudy)
SFMR (limitation: only surface level)

B. Moisture:
  - Dropsondes/rawinsondes (limitation: spatial resolution)
  - Microwave radiometric/interferometry (limitation: vertical resolution)
  - Aircraft in-situ (limitation: one level)
  - DIAL LIDAR (NASA LASE)

C. Temperature:
  - Dropsondes/rawinsondes (limitation: spatial resolution)
  - Radiometric/interferometry (limitation: vertical resolution)
  - Aircraft in-situ (limitation: one level)
  - Microwave (NASA MTP)

D. Ocean thermo:
  - AXBT/drifters (limitation: spatial resolution)
  - Satellite IR (limitation: no data in cloudy regions)
  - Satellite altimetry (limitation: model interpretation)
  - Aircraft/satellite microwave

E. Rain/microphysics:
  - Buoys/ground stations (limitations: one level, limited spatial coverage)
  - Radar/polarization diversity (limitations: vertical resolution, view near coastline, calibration between radars)
  - SFMR rain rate (limitation: integrated column)
  - Aircraft in-situ microphysics (limitation: one level)
  - Satellite (limitation: cloud/no cloud)
  - Profilers and sub-millimeter radars

F. Ocean waves:
  - Radar altimetry (SRA)
  - Laser altimetry (limitation: only when no cloud or precipitation)
  - Fixed/drifting buoys (limitation: spatial resolution)
  - SAR imaging

G. Ocean currents:
  - AXCP (limitation: spatial resolution)
  - SAR interferometry
  - CODAR (limitation: only near coastline)
  - Fixed/drifting buoys (limitation: spatial resolution)

H. Radiation:
  - Satellite VIRS
  - Aircraft in situ aerosol

III. Flight strategies:

A. To achieve radial resolution need long radial legs to at least 450 km to resolve the radius of 35 kt winds.

B. To achieve the wave #2 azimuthal coverage need at least 3 legs crossing the For Differential Analysis need at least 12 h repeat cycle.

C. Altitude should be as high as possible, although it is not clear that 12 km is optimum. It is clear that 6 km may be too low, particularly for moisture and temperature structure.

IV. Instrumentation upgrades needed: (in priority order)

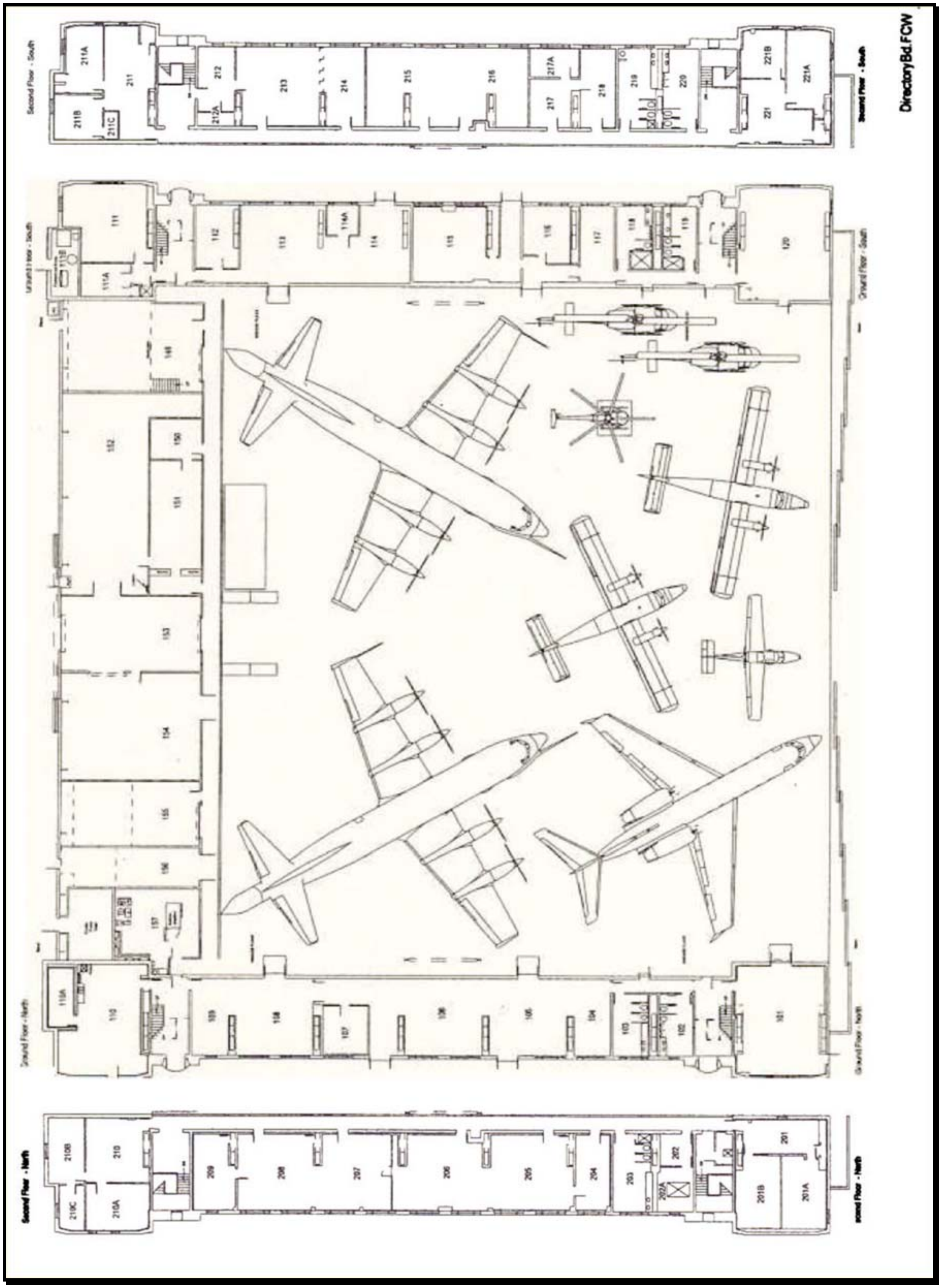
A. Communications to the ground to transfer the data to the model DAS – need a secure high-speed (at least 9600 bd) data communications link to the ground. Systems on the WP-3D currently are 100 bd ASDL, 2400 bd INMARSAT, and 9600 bd Globalstar. G-IV has 2/2400 bd INMARSAT systems and looking at 64000 bd upgrade. Need to interest NESDIS in this issue as they have the most experience.

B. Doppler wind capability: WP-3D has the ideal system, but doesn't fly high enough for the moisture and temperature requirements. G-IV has a nose radar that has Doppler capability, but not in the vertical. Looking at test of vertically pointing scanning Doppler radar (airborne profiler) for G-IV.

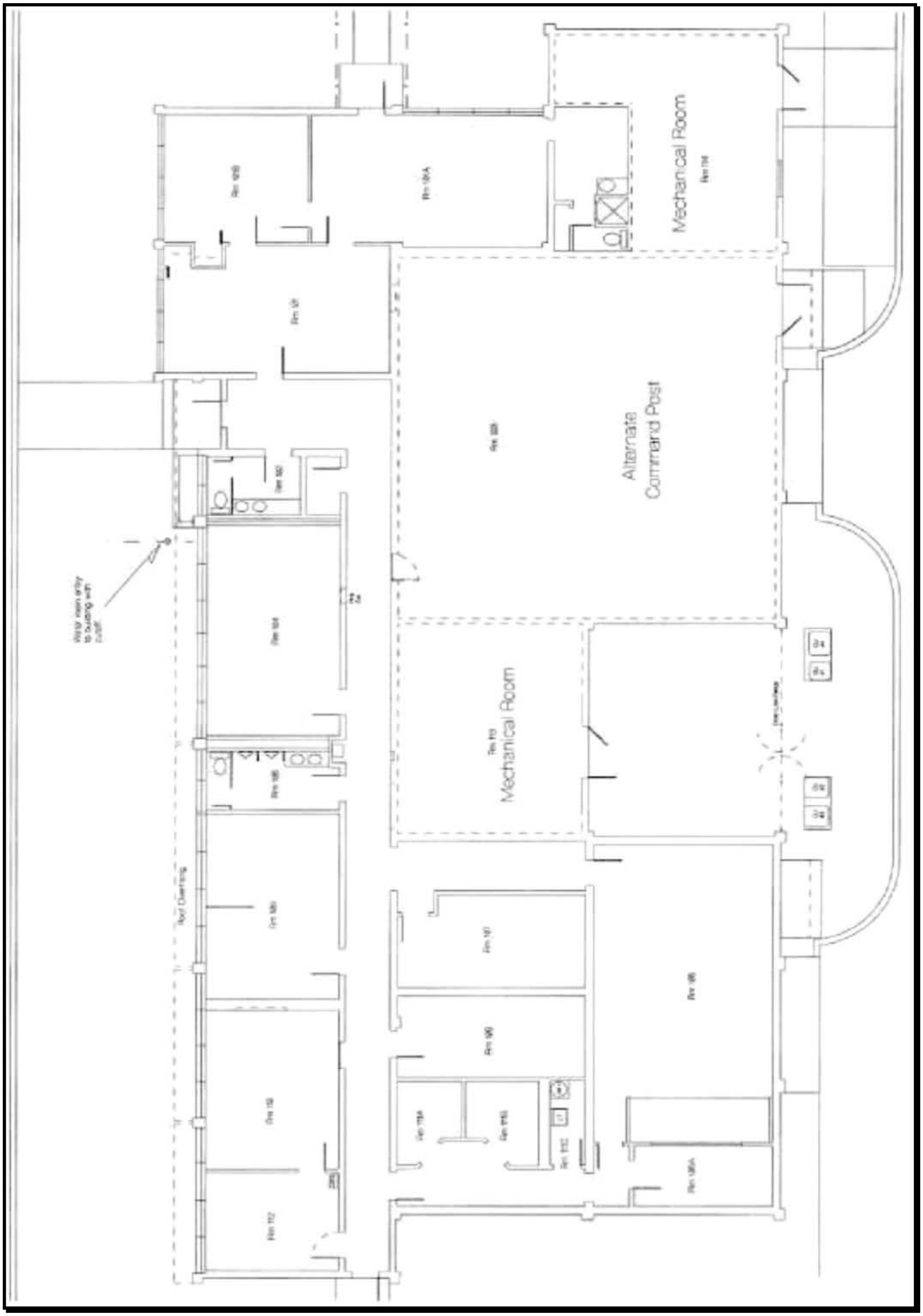
C. Moisture profiling: NASA (through CAMEX) has developed DIAL Laser Temperature profiles: NASA (through CAMEX) has developed microwave temperature profiler (MTP) system for use on DC-8 and ER-2. Provides continuous vertical temperature profiles 4-5 km above and below aircraft along flight track. Should be suitable for AOC aircraft.

D. Surface wind and rain: HRD and UMASS have developed SFMR to provide surface wind and rain estimates. Working with AOC on version that could be used on all AOC aircraft.

Appendix C
Aircraft Operations Center Facility Diagrams



Hangar 5



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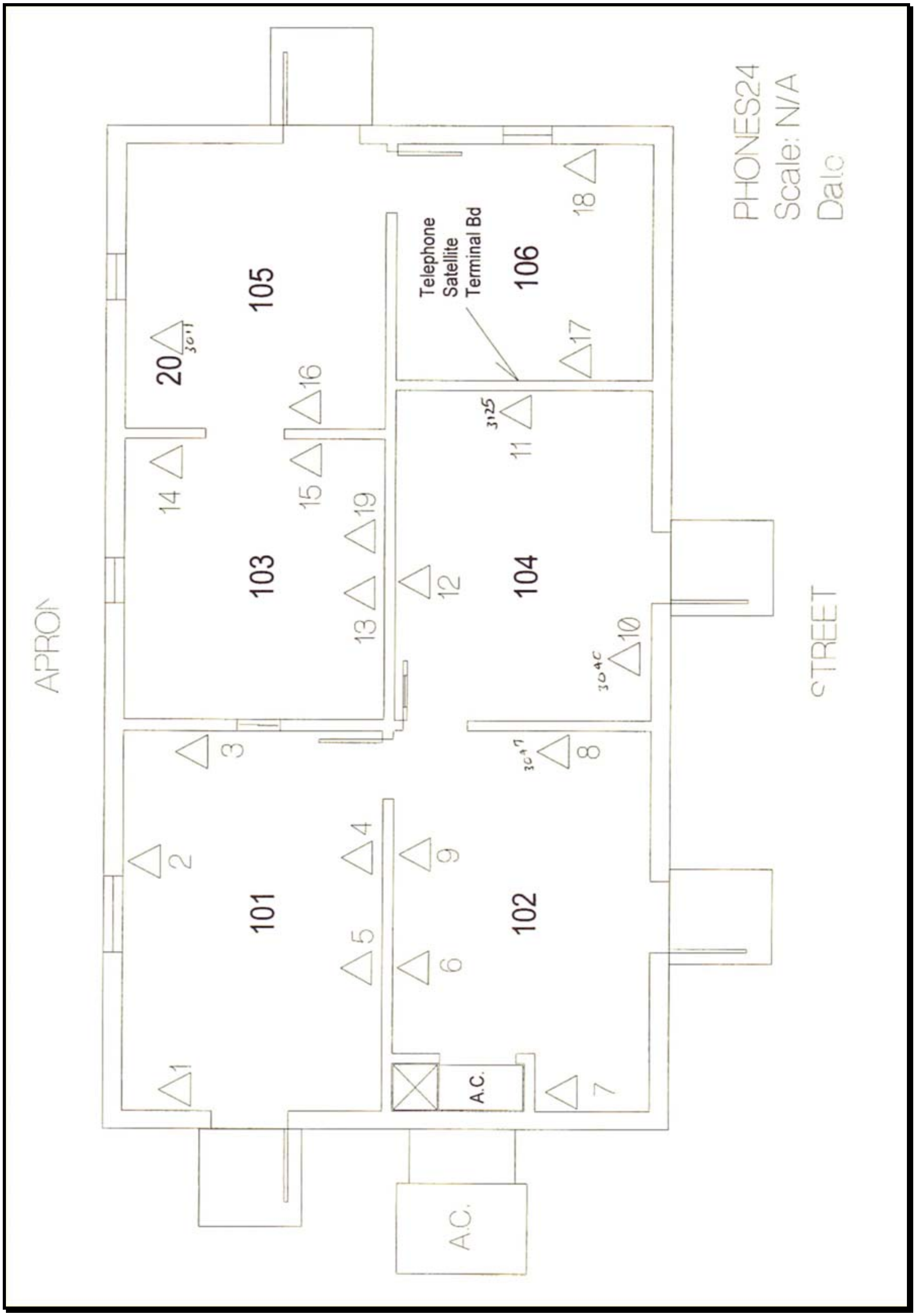
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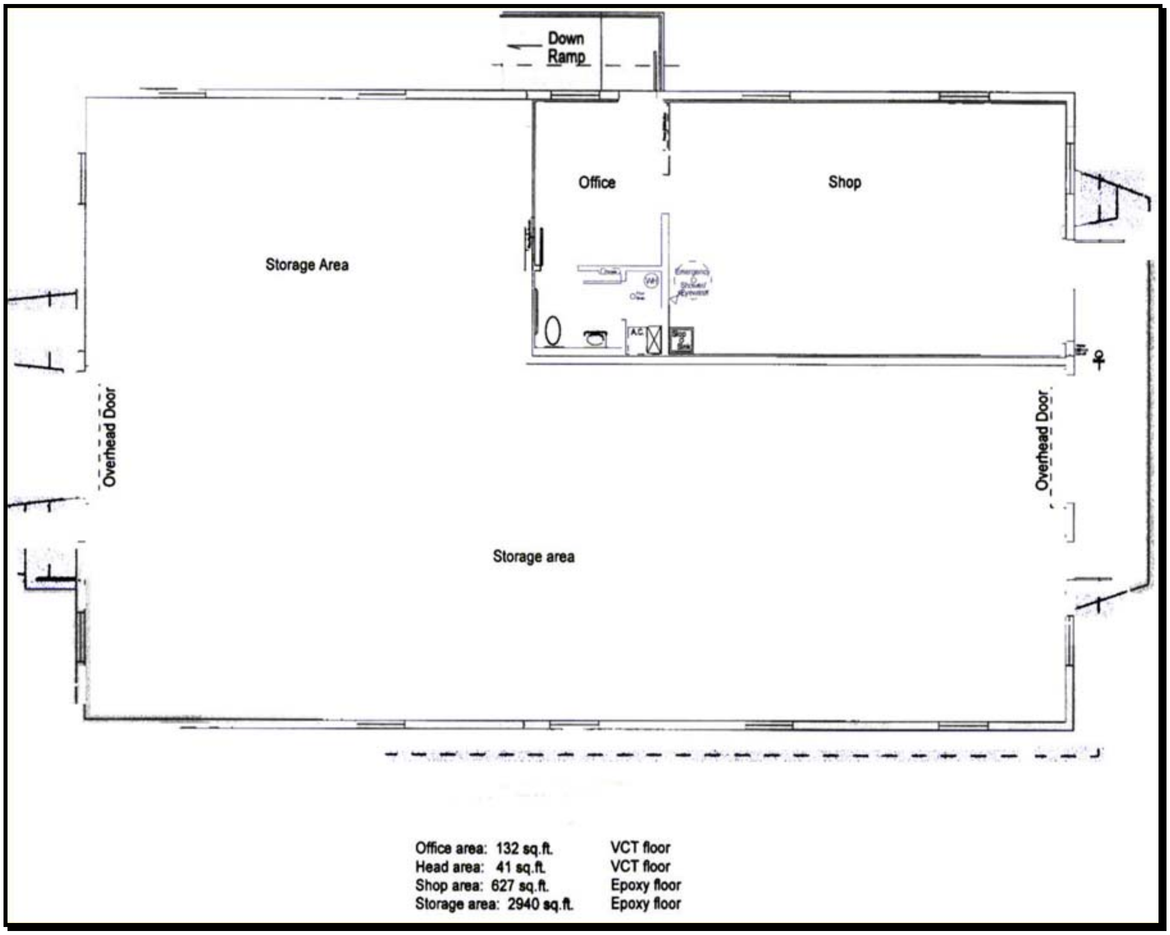
Building 24


Down
Ramp
Office
Shop
Storage Area
Overhead Door
Overhead Door
Storage area
Office area: 132 sq.ft.
Head area: 41 sq.ft.
Shop area: 627 sq.ft.
Storage area: 2940 sq.ft.
VCT floor
VCT floor
Epoxy floor
Epoxy floor

Building 44


1/11/2002 12:15

Appendix D

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